SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

JUNE 1900.

GENERAL PHYSICS.

1232. *Connection between Ether and Matter.* **G. Sagnac.** (Soc. Franc. Phys., Bull. 138. pp. 2–3, 1899.)—The propagation of light across matter may be explained without supposing that the ether in the neighbourhood of matter has any other properties than it has in a vacuum. The material particles behave like small perfect conductors, each of which reflects or diffracts the electric vibrations of suitable wave-length. The author shows that, without entering upon any electromagnetic or dynamical considerations, the geometrical laws of reflection and refraction may be deduced from purely kinematical principles. The optical phenomena of the dragging of ether by matter are easily explained, without postulating a greater local density of the ether or any mechanical action between ether and matter. The kinematical theory is in agreement with the facts of dispersion and double refraction, and no difficulty is presented by the phenomena of anomalous dispersion.

E. E. F.

1233. *Density and Elasticity of the Ether.* **R. A. Fessenden.** (Phys. Rev. 10. pp. 1–33, Jan., and 83–115, Feb., 1900.)—The main object of this paper is to establish the nature of the electromagnetic quantities. But, having shown that magnetic permeability is the reciprocal of an elasticity and dielectric constant is a density it is adduced as a consequence that the density and elasticity of the ether are respectively 0·66 gm. per c.c. (or two-thirds that of water) and 6×10^{20} respectively. These results are obtained on the hypothesis that the ordinary matter and the ether may be likened to small framework structures of platinum and to oil respectively. Hence, while the elasticity of the oil is not sensibly affected by the presence of the platinum wires, the density of the latter must be added to that of the oil to obtain the total density now in question.

The resultant velocity of wave-propagation in the space occupied by the combination would therefore be given by—

$$v^2 = R/(d + D), \qquad (1)$$

where d is the density of the oil, D the mass of the platinum wire structures per cc. of space, and R the elasticity of the oil.

In this case, if the oil were set in motion with a velocity v, the velocity of the waves through it would be increased by the amount

$$v\,\mathrm{D}/(\mathrm{D}+d).$$

This fraction is of the same form as that called for by the aberration of light and Fizeau's experiment. Consequently, taking κ to be a density, we should have for all substances the fraction $(\kappa - \kappa_e)$/density, approximately equal to a constant, where κ_e denotes the dielectric constant of the ether. There are exceptions, such as water and the alcohols, but by far the greater majority of substances obey this law. Now since κ denotes the dielectric constant, and therefore the density, both of the stuff and the space occupied by it, and, according to our present system, that of the ether alone is unity, therefore $(\kappa - 1)$ is the density of the material in terms of the density of the ether. Now the average value of the constant, $\frac{\kappa - 1}{\text{density}}$, is 1·5, therefore the value of the density of the material in terms of the density of the ether is 1·5 times its density in terms of water, *i.e.*, the density of the ether is 0·66, or two-thirds that of water. The elasticity is then deduced from the known velocity of light.

Conversely it follows that to find the dielectric constant of any substance, it is sufficient to add its specific mass to that of the ether and then divide the sum by 0·66. Thus, to get the dielectric constant of a mineral oil of density 0·5, we get—

$$(0{\cdot}5 + 0{\cdot}66) \div 0{\cdot}66 = 1{\cdot}75 = \kappa.$$

[The remainder of this paper is dealt with in Abstracts Nos. 1234, 1235, 1277, 1278, and 1279 (1900).] E. H. B.

1234. *Size of Atoms and their Ionic Charges.* **R. A. Fessenden.** (Phys. Rev. 10. pp. 1–33. Jan., and 83–115, Feb., 1900.)—In the course of an investigation directed chiefly to other ends the author is incidentally led to discuss the size and properties of atoms and their ionic charges. He thus arrives at the following inferences :—

(1) The space occupied by the atoms of a metal to the exclusion of other atoms is of an approximately spherical shape at ordinary temperatures. (2) The atoms of a metal, when in a solid state, are not widely separated, but the shortest distance between the surfaces of two adjacent atoms is of the order of 1 per cent. of the diameter of the atom itself, when at temperatures not near the fusing-point. (3) Metalloids differ from metals in that their atoms have not an approximately spherical shape. (4) The melting-point and expansion of the elements is a function of the shape of their atoms. (5) The diameter of the mercury atom is $2{\cdot}75\ (\pm 0{\cdot}2)\ 10^{-8}$ cm. (6) The ionic charge is $4\ (\pm 1)\ 10^{-10}$ *E.S.* units. (7) Chemical action and cohesion are both manifestations of the same force, *i.e.*, electrostatic attraction, under different conditions. (8) If we take wires of two pure metals, having an equal number of molecules in the cross section, then the electrical resistances of the wires will be proportional to the times taken by a sound wave to traverse them. Van der Waal's equation is also examined in the light of this theory and the constant a shown to be a function of the volume b, so that the equation would be modified thus—

$$\left(p + \frac{c}{b^{4/3}}\right)(v - b) = \mathrm{RT}.$$

[The remainder of this paper is dealt with in Abstracts Nos. 1233, 1235, 1277, 1278, and 1279 (1900).] E. H. B.

1235. *Elasticities of Substances in terms of their Atomic Volumes.* **R. A. Fessenden.** (Phys. Rev. 10. pp. 1–33, Jan., and 83–115, Feb., 1900.)—On the author's theory of atoms the following formulæ hold :—

(1) Rigidity $= 28 \times 10^{12} \div (\text{atom. vol.})^2$.

(2) Young's Modulus $= 78 \times 10^{12} \div (\text{atom. vol.})^2$.

(3) Velocity of Sound $= \left\{78 \times 10^{12} \div (\text{atomic wt.} \times \text{atom. vol.})\right\}^{\frac{1}{2}}$.

These are supported by tables showing a fair agreement between the experimental and theoretical values for iron, copper, platinum, zinc, silver, gold, aluminium, cadmium, magnesium, tin and lead.

[The remainder of this paper is dealt with in Abstracts Nos. 1233, 1234, 1277, 1278, and 1279 (1900).] E. H. B.

1236. *Impact Tests of Material in Tension.* **W. K. Hatt** and **E. Marburg.** (Eng. News, 43. pp. 74–75, Feb. 1, 1900. From a preliminary report read before the American section of the International Association for Testing Materials.)—The authors briefly review the early experiments, and the more recent experiments of Kirkaldy and Le Chatelier. They then describe some slow tension-tests and tests in longitudinal shock made at Purdue University during the past two years on iron and steel wires from ⅛ inch to ⅓ inch diameter, ranging in length from 4 feet to 9 feet. The machine used is of a type in which the hammer is hung on the specimen and impact takes place at the upper head. The hammer varies from 845 to 1,230 lbs., and the range of motion is from ¼ to 7 feet. The anvil on which impact occurs at the upper head consists of two oak pieces 4 inches square in section bridging the 20 inches clear span between the uprights of the machine, supporting a cast-iron block 14 in. × 18 in. × 6 in., which in turn supports a steel block 4 in. × 4 in. × 14 in. A pencil attached to the hammer describes a curve on the surface of a revolving drum, whose speed is determined by the record of a tuning-fork. The total elongation of the specimen is thus recorded on the drum, as well as the velocity of the weight before and after impact. A summary of the observations shows that the ultimate extension, contraction of area and resilience were not different for Norway iron and medium steel wire ⅓ inch diameter under slow loading and under impact. One specimen broke in two places, and in other cases more than one neck developed in the specimen. In impact on wires of smaller diameter, the elongation in different foot-lengths varied irregularly, while in slow tension-tests on the same material the elongation decreased regularly on each side of the fracture. In thick wires the elongation was as uniformly distributed in slow as in rapid tests.

Detailed results will be published when the investigation is sufficiently advanced. A. S.

1237. *Elasticity and Strength of Copper.* **C. Guidi.** (Accad. Sci. Torino, Atti. 35. 6*a*. pp. 223–230, 1899–1900.)—This paper contains the results of experiments on the elasticity and resistance to tension of bars of copper made from plates employed in the construction of the fire-box of a locomotive. It is known from the experiments of Bach that repeated tests of ever-increasing intensity increase the elasticity of a bar. Owing to variations of pressure within the boiler the plates of a fire-box are subjected to varying strains. The increase in elasticity, however, in the cases studied is not large, and the elasticity is less than half of that which can be obtained artificially by the method of Bach. Tables and curves accompany the paper. A. G.

1238. *Viscosity of Argon as Affected by Temperature.* **Rayleigh.** (Roy. Soc., Proc. 66. pp. 68–74, March 3, 1900.)—The author prefaces the account of his experiments with some interesting theoretical considerations. After having shown why one might expect the Maxwell law to hold, *i.e.*, the non-dependence of μ (viscosity-coefficient) on density, it is shown that if this law be assumed, and if the repulsive force between the molecules vary as r^{-n}, then for a given kind of molecule $\mu \propto \theta^{\frac{n+3}{2n-2}}$, where $\theta =$ temperature. This theorem is proved in a very simple manner by an application of the method of dimensions. For the case of sudden impacts, $n = \infty$ and $\mu \propto \theta^{0 \cdot 5}$. But the best experiments on air show that $\mu \propto \theta^{0 \cdot 77}$. In the hope of obtaining a better agreement between theory and experiment in the simpler case of *monatomic* molecules experiments were made on the viscosity of argon at room temperature (15° C.) and at the temperature of boiling water (100·27° C. in this particular case). The method of flow through a capillary tube was employed. The capillary tube was nearly 5 feet long, and was surrounded by a jacket through which steam could be passed. All joints were blown. The experiments being comparative, it was not necessary to keep the driving pressure constant. The mean of the time measurements was correct to $\frac{1}{10}$ sec. These means were: 15° C., 104·67 secs.; 100·27° C., 167·58 secs. This gives $n = 0 \cdot 812$ in the formula $\frac{\mu'}{\mu} = \left(\frac{\theta'}{\theta}\right)$, when $\theta =$ absolute temperature. Corrected for the expansion of the glass, this becomes 0·822. The following table embraces the results of an extended series of observations :—

Air (dry)	0·754
Oxygen	0·782
Hydrogen	0·681
Argon (impure)	0·801
Argon (best)	0·815

The numbers in this table are the values of n in the above formula, corrected for the expansion of the glass.

It will be seen that the value of n for argon is not equal to values such as 0·5 or 1, to which theoretical considerations lead. F. G. D.

1239. *Argon Passing through Rubber Films.* **Rayleigh.** (Phil. Mag. 49. pp. 220–221, Feb., 1900.)—Graham found that when air was allowed to percolate through rubber films into a vacuum, the oxygen percentage instead of being 21 was about 40. The author finds the mean percentage to be 37. Of 3,205 c.c. of percolated air 1,185 was oxygen, and of the remaining 2,020, 1,981 consisted of nitrogen and was oxidised out, leaving 39 c.c. of argon, or 1·93 per cent. of the 2,020. In atmospheric air the proportion of argon in the mixed nitrogen and argon is (Kellas) 1·19 per cent. Argon, therefore, passes through an indiarubber film more readily than nitrogen, but not in such degree as to render the diffusion process a useful one for the concentration of argon from the atmosphere. A. D.

1240. *Theory of Diffusion.* **O. Wiedeburg.** (Zeitschr. Phys. Chem. 30. pp. 586–592, Dec. 30, 1899.)—This paper is to some extent a criticism, and to some extent a continuation of an article by E. Bose (see 1900, Abstract No. 15). For the criticism, which chiefly refers to certain implicit assumptions, reference should be made to the original paper. An endeavour is made to calculate the value of the velocity of a gramme-molecule (un-ionised) of a substance dissolved in water when subjected to a unit force. The variation of the coefficient of diffusion with change of concentration may be expressed by the empirical equation $D = D_0(1 + \gamma c)$, where D is the value for concentration c, and D_0 the value for zero concentration, γ being a constant which depends on the nature of the solution. When $\frac{4c}{k}$ (for meaning of k and other symbols see the Abstract mentioned above) is small compared with unity, it can be shown that $W = (2 + \gamma k)\frac{UV}{U + V}$ approximately. The smaller γ and k, the more accurate the simple formula $\frac{1}{W} = \frac{1}{2}\left(\frac{1}{U} + \frac{1}{V}\right)$. A shot is made at the value of W in the case of an aqueous solution of salt at 18°, of such a strength that the grade of dissociation is one-half. Taking U and V in the usual units (reckoned for infinite dilution), the respective values are 41×10^{-7}, 62×10^{-7}; and W (the value of γ being obtained from certain experiments of Wroblewski) comes out to be 54×10^{-7}. A. G.

1241. *Electrification and Surface Tension.* **E. Merritt** and **S. J. Barnett.** (Phys. Rev. 10. pp. 65–73, Feb., 1900. Paper read before the American Physical Society, Dec. 28, 1899.)—Since the electro-capillary phenomena occurring at the interface between a liquid metal and an electrolyte, as in a capillary electrometer, are due almost entirely to true alterations of surface tension resulting from the chemical changes of electrolysis, it is interesting to inquire whether there are any alterations of surface tension produced directly by electrification. In a charged soap-bubble the expansion is not due to a diminution of the surface tension, but to electrostatic forces. To eliminate the latter the surface tension was studied by Barnett's method of capillary ripples, a surface of water or mercury being made one armature of a condenser, while a metallic plate forming the other was mounted above it. The velocity of propagation of the ripples with or without electric charge was such as to show no perceptible direct variation of the surface tension, after allowing for the effect of the electrostatic force. E. E. F.

1242. *Internal Friction of Water.* **G. Pacher.** (N. Cimento, 10. pp. 435–443, 1899. From Atti del R. Instituto Veneto, 58. 2. pp. 784–814, 1898–1899.)—In the neighbourhood of 4° the coefficient of viscosity of distilled water presents an anomaly which expresses itself in a flexure of the curve of the coefficient as a function of the temperature. The anomaly in question consists of a maximum and a minimum between 4° and 5°. In view of the connection known to exist between the viscosity and the resistance it is very probable that a similar anomaly occurs in the resistance of distilled water and of aqueous solutions. The author suspects a connection between the anomaly described and the anomaly in the resistance of aqueous solutions discovered by Lussana. E. E. F.

1243. *Electric Thermostat.* **W. Duane** and **C. A. Lory.** (Amer. Journ. Sci. 9. pp. 179–182, March, 1900.)—An electric thermostat is employed by the authors capable of keeping the temperature of a bath of 150 litres capacity constant to within 0·0005° C. The bath is filled with a solution of common salt and heated by an alternating current, the circuit being opened or closed by a mercury contact actuated automatically by the expansion and contraction of alcohol contained in a system of brass tubes immersed in the bath. The apparatus can be adjusted to any required temperature, and is extremely sensitive, opening and closing the circuit several times per second if the temperature tends to vary. L. B.

1244. *Mechanical Principles of Flight.* **Rayleigh.** (Manchester Lit. and Phil. Soc., Mem. 44. 5. pp. 1–26, 1899.)—This lecture is occupied chiefly with the mechanics of soaring, or the sailing flight of birds with motionless wings. It was previously shown, in 1883, that "whenever a bird pursues his course for some time without working his wings we must conclude either (1) that the course is not horizontal; (2) that the wind is not horizontal, or (3) that the wind is not uniform." The third case is most fully discussed. In a uniform wind the available energy at the disposal of the bird depends upon his velocity *relatively* to the air about him. Thus elevation may be gained proportional to the loss of relative velocity squared. Let the wind blow horizontally with velocity $+u$ above a certain plane and velocity $-u$ below it. Let a bird sailing above the plane of separation have initial relative velocity v and consider how he might take advantage of his circumstances. Let him first, if necessary, turn round until the relative motion is down wind in the upper stratum, and, second, drop through the plane of separation. In passing through this plane there is a really effective gain. In entering the lower stratum the relative velocity is increased from v to $v + 2u$. This corresponds to a gain of potential elevation equal to $2u(u + v)/g$. At this stage the bird is moving against the direction of the wind in the lower stratum. He next turns round so as to be with the wind of the lower stratum and contrary to the wind of the upper stratum. A passage upwards through the plane now secures another gain of relative velocity, or of potential elevation, of nearly the same value as before. An example is given showing that a difference of wind-velocity of 4·7 miles per hour above and below the plane of separation corresponds to a potential elevation of 10 feet each time the bird crosses the plane properly with a speed of thirty miles per hour. The article also shows how a bird may take advantage of the *gustiness* of the wind. The behaviour of aeroplanes is next discussed at some length, both mathematically and experimentally.

E. H. B.

1245. *Lecture Demonstrations of Wave Motion.* **W. C. Baker.** (Phys. Rev. 10. pp. 175–177, March, 1900.)—A mercury tray, 72 × 55 × 7 cm., whose smooth bottom is painted white, is filled to a depth of about half a centimeter with water, slightly darkened with ink. The discoloration of the water must be such that the bottom of the tray is clearly visible through the layer of liquid when at rest. If a beaker or other round vessel of 8 to 10 cm. diameter is placed in the tray a circular wave is set up that spreads in all directions. The motion of this wave can be clearly followed, as the thickness of the liquid at the crest of the wave being so much greater than at the trough, the appearance is that of a dark band travelling over a lighter background. The removal of the beaker gives a second wave, so if the beaker be kept moving with a period of one or two seconds a train of waves of the same period is produced. The use of single waves or trains of only two or three is advocated in order to avoid interference effects after reflection at the sides. These circular waves travel at from 15 to 25 cm. per sec., and the growth of the waves reflected from the sides of the tray can easily be followed on account of their slow motion. Waves approximately plane are obtained by using a a block of wood about 50 × 8 cm. instead of the beaker. A semicircular piece of barrel hoop placed at one end of the tray plays the part of a concave or convex mirror. Refraction phenomena are represented by the use of a piece of window glass, say 60 × 12 cm. placed about 1 mm. below the surface of the liquid and strictly parallel thereto, care being taken that its surface is thoroughly wet. Trains of circular waves passing over this shoal travel slower, decrease in curvature, and have a smaller wave-length. Following the same principles refraction through prisms and lenses may be imitated and illustrations of Huyghens' principle and diffraction readily given. E. H. B.

1246. *Variation of Atmospheric Pressure and Moon's Declination.* **R. Börnstein.** (Phys. Zeitschr. 1. pp. 54–56, 1899. Report read before the Naturforscherversammlung in Munich.) — The variations of standard barometers have been carefully studied for eighty sidereal months (from January 1, 1893, to December 24, 1898, and the results plotted in comparison with the different positions of the moon in declination at Berlin, Magdeburg, and Potsdam. It is found that a *maximum* pressure generally occurs about the eleventh or twelfth day of the lunation, and a *minimum* about the twenty-third, the amplitude of the variation depending on the latitude of the place. For example :—

Amplitude at Berlin (52° 31′ 54·3″ N.) = 2·851 mm.
„ Magdeburg (52° 7′ 46″ N.) = 2·764 mm.
„ Vienna (48° 15′ N.) = 1·853 mm.
„ Upsala (59° 51·5′ N.) = 1·945 mm.
„ San Fernando (36° 27′ 41·5″ N.) = 0·768 mm.
„ Port au Prince (18° 34′ N.) = 0·692 mm.
„ Batavia (6° 11′ S.) = 0·141 mm.

C. P. B.

REFERENCES.

1247. *Aerial Locomotion.* **H. Wilde.** (Manchester Lit. and Phil. Soc., Mem. 44. 11. pp. 1–16, 1900.)—Consists chiefly of descriptions of experiments in aeronautics which have yielded only negative results. A parachute with vibrating framework is suggested as a possible solution of the problem. E. H. B.

1248. *Construction of the Curve $PV^n = C$.* **D. A. Low.** (Mech. Eng. 5. pp. 292–293, March 3, 1900.)—A paper describing a simple method of drawing any number of curves of the form $PV^n = C$, and showing how to find out whether a given curve is of this form, and if so, showing how to find the value of the index *n*. A. S.

1249. *Horizontal Pendulum in Seismometry.* **G. Agamennone.** (Accad. Lincei Atti, 9. pp. 107–114, Feb. 18, 1900.)—This paper describes various examples. A. G.

LIGHT.

1250. *Nature of White Light.* **E. Carvallo.** (Comptes Rendus, 130. pp. 401–403, Feb. 12, 1900.)—The author proposes the following crucial experiment, whose realisation is conceivable, to decide the point at issue between M. Gouy and himself [see Abstracts Nos. 817, 818, 819 (1900)] : Let the spectroscope be reduced to a concave grating, and let the grating be enlarged in the proportion of sound waves to visible light waves. Finally, let the source of light be replaced by a tuning-fork. If the tuning-fork is electrically driven, it will produce a sinusoidal wave train. At the focus of the spectroscope, we should find sonorous points corresponding to the rays emitted by monochromatic light. Let the tuning-fork be stopped. Its vibrations will be damped, and certain processes permit of the variation and regulation of the damping. If, under such circumstances, a sound spectrum is found to exist, there will be a confirmation of Gouy's views. If, on the other hand, the sound is everywhere the same, with an intensity varying according to the point of the focal surface, and the sound is extinguished with the vibration of the tuning-fork itself, then the author's own views are verified. E. E. F.

1251. *Duration of Faraday Effect.* **H. Abraham** and **J. Lemoine.** (Comptes Rendus, 130. pp. 499–501, Feb. 19, 1900.)—By the method used for determining the duration of the Kerr effect (see 1899, Abstract No. 1859), the authors have also tested the existence of a time-lag in the Faraday effect. They find that the magnetic rotatory polarisation decreases by one-half in 1/100th of a micro-second, and is nearly zero after the lapse of double that time. Practically, therefore, both the Faraday effect and the Kerr effect follow the changes of the field without retardation. E. E. F.

1252. *Spectrum of Cyanogen.* **W. N. Hartley.** (Roy. Dublin Soc., Proc. 9. pp. 289–297, April 7, 1900.)—The paper chiefly consists of a reply by the author to a criticism of his former work by Eder and Valenta. He also describes his observation of the cyanogen bands in the spectrum of an oxy-coal-gas flame, the presence of the cyanogen being subsequently proved chemically by passing the gas through alkaline ferrous sulphate and final precipitation of Prussian blue in the usual manner. C. P. B.

1253. *Reference-Points in Spectra.* **M. Hamy.** (Comptes Rendus, 130. pp. 700–701, March 12, 1900.)—The author refers to a previous paper by Fabry and Perot, in which they imply that the red lines of cadmium used by Hamy and Michelson are not identical. Hamy explains this by stating that with Michelson's tube containing *internal* electrodes the red cadmium line at λ 508 is a doublet, one component strong, the other feeble; with external electrodes to the tubes, however, Hamy finds this same line to be a triplet, or a doublet having equal components, with a simple line on the less refrangible side. For practical work he finds these tubes without internal electrodes much more constant than the usual form. C. P. B.

1254. *Series in Spectra.* **E. A. Partridge.** (Frank. Inst., Journ. 149. pp. 193–206, March, 1900.)—A most useful review of the present state of knowledge respecting spectral series, containing references to most of past publications on the subject, from Lecoq de Boisbaudran's first paper in 1869 to the present time. The nearest approach to an accurate formula was that of Balmer, in 1885, which was, however, only applied to the hydrogen spectrum. In 1888 Kayser and Runge, of Hanover, announced the discovery of a more universal formula, of which that of Balmer was a special case, and from that time they have been engaged in successively photographing the elements of the various periodic groups and searching their spectra for series. It is found that the percentage of lines falling into series in any spectrum is almost inversely proportional to the melting-point of the element. The contemporaneous work of Humphreys on the effect of pressure on change of wave-length goes to confirm much of Kayser and Runge's series determinations, as he finds that all the lines in any one series have the same "displacement" due to pressure, but the amount varies for the different series. C. P. B.

1255. *Anomalous Dispersion in Infra-Red.* **E. Aschkinass.** (Phys. Zeitschr. 1. pp. 53–54, 1899. Report read before the Naturforscherversammlung in Munich.)—This paper is similar to that noticed in Abstract No. 626 (1900), but gives a few further results. Thus bands of anomalous dispersion occur at the following positions :—

Calcspar	6·67 μ and 11·40 μ.
Marble	6·69 μ „ 11·41 μ.
Gypsum	8·69 μ.
Alum	9·05 μ.
Sodium bromide	50–55 μ.

C. P. B.

1256. *Fluorescence of Metallic Compounds caused by Röntgen and Becquerel Rays.* **P. Bary.** (Comptes Rendus, 130. pp. 776–778, March 19, 1900.)—The only salts, besides the phosphorescent uranium salts, which show fluorescence under the action of the Röntgen rays are compounds of the alkali or alkaline earth metals. On all these substances, a list of which is given, the Becquerel rays exert a similar action. T. H. P.

1257. *Radio-active Bodies.* **M.** and **Mme. Curie.** (Soc. Franç. Phys., Bull. 142. p. 6, Jan. 19, 1900.)—Polonium (which chemically resembles bismuth) falls off slowly in its radio-active power. Radium (similar to barium) seems to have a higher atomic weight than barium, for the atomic weight of barium seems higher (146) in radiferous barium compounds than it does (137) in compounds free from radium. The solid compounds of radium become more radio-active as time goes on, and do not reach their maximum activity within a month ; their initial condition is restored by dissolving them and recrystallising. The chloride and bromide of radium are the most brightly luminous compounds ; but all the salts are so to some extent. Induced phosphorescence and induced radio-activity in the neighbourhood of radium as described by Becquerel were discovered by the authors. Radium rays act in many ways like light ; they reduce silver salts, peroxide of iron, and bichromate of potash in presence of organic substances : but they also colour glass, porcelain, and white paper, and they transform greenish-yellow platinocyanide of barium into a brown variety. **Giesel** had prepared platinocyanide of barium with a trace of radium ; this spontaneously became brown and then it polarised light like tourmaline. He also found that radium rays coloured rock-salt just as kathode rays do, or the vapours of the alkaline metals; and further, that radium salts, brought near to the temples or to the closed eyes, produced a sensation of light. A. D.

1258. *Curvature of Becquerel Rays.* **R. J. Strutt.** (Roy. Soc., Proc. 66. pp. 75–79, March 8, 1900.)—This is an attempt to compare the magnetic deflections of Röntgen, Becquerel, and kathode rays. The author entirely failed to obtain any sign of the magnetic deflection of Röntgen rays. He can assert with certainty that with a field of 3,270 c.g.s. units no perceptible deflection is obtained, and in view of the probable limit of sensitiveness of his apparatus, he says that to produce a curvature of radius 1 cm. in Röntgen rays a magnetic field would be required of at least 60 million units. Thomson has found that to produce the same curvature in kathode rays a field of only 315 units is required. Becquerel rays stand between Röntgen and kathode rays in this respect. The author arrives at an estimate of their curvature by placing a little lead box containing a uranium preparation on its side on a sensitive plate in a magnetic field. The box is only half full, and he adjusts the magnetic field until the rays are so deflected away from the plate that they only just graze the surface. It is then easy to draw the trajectory of the highest ray. A field of 1,680 units gives a field of curvature 3 cm. Hence a radius of 1 cm. would require 5,000 units. E. E. F.

1259. *Phosphorescence under Radium Radiations.* **H. Becquerel.** (Journ. de Physique, 9. pp. 65-70, Feb., 1900.)—Many recognised fluorescent substances become luminous in the neighbourhood of radium compounds: those excited by luminous rays (ruby and some calcareous spars) do not; those excited by ultra-violet rays or by Röntgen rays do so as a rule, but not in all cases or with equal intensities. There appears to be a certain amount of absorption by the air. The same screens have different effects in reducing the phosphorescence excited in different substances, so that each phosphorescence appears to be excited by a different part of the radium radiations. In some minerals the phosphorescence excited by radium is very persistent. Radium has the same power as the electric spark, or the prolonged action of violet or ultra-violet rays, of restoring the phosphorescent properties, under exposure to heat, of a body deprived of them by over-heating. Phosphorescence, and the temporary acquisition of a power of rendering air a conductor, both induced by radium radiations, are phenomena independent of one another: fluorspar may be deprived of the latter power by washing it in water, without affecting its phosphorescence. **Wyrouboff** pointed out (Soc. fr. Phys., Bull. 140, discussion, pp. 3–4, 1899) that the phosphorescence of fluorspar was a complex phenomenon; that the colours of spar were due to hydrocarbons and that white specimens did not phosphoresce on heating, and that if the hydrocarbons are destroyed by heat the spar can no longer fluoresce; and that therefore the action is a chemical one, which, however, is not combustion, for it is unaffected by an atmosphere of carbonic acid or of hydrogen. **Villard** pointed out that as to the violet colour induced in fluorspar by kathode rays (but not obtained by Becquerel with radium rays), this was not of the same nature as the violet coloration induced in glass by radium rays (M. and Mme. Curie); in the former case a subsalt is formed, in the latter there is oxidation of manganese. **H. Le Chatelier** said that as to this oxidation of manganese there was no occasion to call in oxygen from without; there was a disturbance of the existing chemical equilibrium between manganous and ferric silicates, a disturbance brought about slowly by sunlight, quickly by radium rays. This chemical equilibrium is properly one pertaining to the high temperature of fused glass, and not to ordinary temperatures: and there is a constant tendency to the disturbance which the radium rays facilitate. A. D.

1260. *Radium Radiations in a Magnetic Field.* **H. Becquerel.** (Journ. de Physique, 9. pp. 71–78, Feb., 1900. Soc. Franç. Phys., Bull. 140. pp. 2–3; discussion, pp. 3–4, 1899.)—The radiations from radium are deviated in a magnetic field, being concentrated upon the poles in a non-uniform field. Rays in the same direction as a uniform field are not deviated; those in a plane at right angles to the field are deviated along circular lines. Between opposed polar faces, when the electromagnet is not excited, the phosphorescence or photographic effect is widespread and weak; when the electromagnet is set in action the area affected is narrowed and the effect is more intense. When the radium compound and the fluorescent substance are arranged on surfaces parallel to the lines of force, putting the electromagnet in action diffuses the effect, and the rays are bent curvilinearly, so that shadows cannot be produced unless this is kept in view. With polonium the predominant result (Curie) is that there is no such deviation. Radio-active bodies, therefore, give out two kinds of rays, deviable and not deviable in a magnetic field. **Curie** pointed out that these properties were like those of kathode rays, while in other respects radium rays were very like Röntgen rays. **Becquerel** replied that the phenomena of phosphorescence brought radium rays near to ultra-violet rays. A. D.

1261. *Radiations from Radium.* **H. Becquerel.** (Comptes Rendus, 130. pp. 206–211, Jan. 29, and 372–376, Feb. 12. Soc. Franç. Phys., Bull. 144, pp. 2–3; discussion, pp. 3–4, Feb. 16, 1900.)—The radiations from radium, transmissible through black paper and deviable by a magnetic field, are deviated to the same extent whether they travel in air or in a vacuum. The different salts of radium give out rays equally deviable, that is to say, of the same nature, and only differing in their intensity. Rays travelling normally to a uniform magnetic field describe a closed trajectory which brings them back to the point of emission: very much as in the case of kathode rays, and as if we had to do with forces acting upon negative electric masses traversing the magnetic field with high velocity. In a magnetic field aluminium and most other substances seem to be more transparent to these rays close to the source than they are at a distance of 2 cm. On the assumption of negative electric masses at high velocities, the masses and charges might be small, but the ratio m/e appreciable. Then as $v.m/e = \mathrm{H}\rho$, where v is the velocity and ρ the radius of curvature of the trajectory, H being found equal to 4,000 and ρ to 0·37 cm., $v.m/e$ would be about 1,500; which is of the same order as the values found for kathode rays by J. J. Thomson, W. Wien, and Lenard. In an electric field of intensity F, the deviation should be $\theta = \mathrm{F}l/(v^2m/e)$, where l is the length of path in the field. No deviation has as yet been obtained; but if v be, as in the case of kathode rays, of the same order as the velocity of light, say one-fourth as great, a deviation of $\frac{1}{5}$ radian or 11·4° on a trajectory of 1 cm. would require a potential difference of 20,000 volts between two plates 1 cm. apart. Experiments under such conditions have not yet been made. The part of the rays from radium deviable by a magnetic field is dispersed along trajectories with different radii of curvature, the absorption of which by different screens varies with the nature and the position of these screens. Even lead is fairly permeable by the rays when quite close to the radium salts. The radium radiations seem to form a kind of continuous spectrum, for each part of which the value of $H\rho$ may be taken as its characteristic, and the absorptions of different substances may be characterised by finding the minimum values of $H\rho$ for the radiations which are transmitted by them. Those rays which have the smallest values of $H\rho$ and are most deviable are the most readily absorbed. **P. Villard** said the anomaly of unequal transparency at distant and at close quarters might be explained on the analogy of kathode rays, where the plate of aluminium interposed is not a simple transmitter of kathode rays, but always sends them normal to its surface, acting as a secondary kathode (J. J. Thomson); and in Becquerel's experiments the interposed plate of aluminium may simply appear opaque to certain rays because these are not sufficiently powerful to set up an analogous secondary action: and at close quarters the apparently transmitted rays may much more nearly resemble the original. A. D.

1262. *Electric Charge of Radium Rays.* **P. Curie** and **Mme. P. Curie.** (Comptes Rendus, 130. pp. 647–650, March 5, 1900.)—The magnetically deflected rays of radium compounds resemble kathode rays rather than Röntgen rays, not only in the matter of magnetic deflection, but also in the fact that they convey a negative charge. This has been proved by the authors in various ways. On account of the complication introduced by the fact that the radiation imparts conductivity to the air or to any other surrounding gas, it was necessary to keep the electrode receiving the radiation sealed up in a non-conducting envelope, against one side of which the radium preparation was pressed. The preparation was contained in a thick-walled leaden box, and was covered with a piece of aluminium foil 0·01 mm. thick. Even after traversing this, and an ebonite layer 0·3 mm. thick, the rays conveyed a current of the order of 10^{-11} ampere through the galvanometer connected with the enclosed electrode. Conversely, when the radium preparation was embedded and the outer metallic envelope put to earth, an electrometer connected with the radium box showed a positive charge which is apparently maintained without loss, and would steadily rise if perfectly insulated. E. E. F.

1263. *Induced Radio-activity.* **E. Rutherford.** (Phil. Mag. 49. pp. 161–192, Feb., 1900.)—All thorium compounds examined produce radio-activity in all solid substances in their neighbourhood if the bodies are uncharged. With charged conductors the radio-activity is produced on the negatively charged bodies. In strong electric fields the radio-activity can be concentrated on the surface of thin wires. Thorium oxide is the most active of the thorium compounds in this respect, but loses its power if it is heated for several hours at a high temperature. The radiation excited is homogeneous and more penetrating than the radiations from thorium or uranium. It is confined to the surface of the substance, and is independent of whether the substance is a conductor or not, and of the nature of its surface. The intensity of the induced radiation falls off in geometrical progression with the time, decreasing to half value in about eleven hours. The decay of intensity is independent of the state of concentration of the radio-activity or the nature of the substance. With time of exposure the induced radio-activity at first increases nearly proportionally, but tends to a maximum value. The amount of radio-activity produced in a given time on a conductor depends on the potential difference between the electrodes and tends to a constant value for large E.M.F.'s. The amount of radio-activity is independent of the pressure of the gas, except at low pressures, when the amount on the negatively charged conductor decreases with the pressure. The amount is not much affected whether the gas is H, air, or CO_2. No increase of weight has been observed by making a body radio-active. The radiation from a platinum wire is not much altered by placing the wire in a frame, in hot or cold water, or in nitric acid. HCl and H_2SO_4 rapidly remove the radio-activity from its surface. Discussion of three possible explanations; (*a*) a kind of phosphorescence excited by radiation from thorium; (*b*) deposition of the positively charged gaseous ions produced in the gas; (*c*) deposition of particles of a radio-active material emitted by thorium compounds. Of these (*a*) will not serve, and between (*b*) and (*c*) the evidence is not conclusive, though (*c*) seems somewhat the more tenable view. The power of exciting radio-activity in this way seems to be confined to thorium compounds. A. D.

1264. *Phosphorescence and Temperature.* **G. le Bon.** (Comptes Rendus, 130. pp. 891–894, April 2, 1900.)—The author has experimented on the phosphorescent power of four radio-active materials having barium bromide for base. All four discharged an electroscope when placed near it. Three of the samples possessed an intense phosphorescence without being exposed to light. The fourth appeared non-phosphorescent, but it became phosphorescent on being placed on a plate heated to 200°. If kept at this temperature it soon lost its phosphorescence. On cooling it did not phosphoresce, and only partially regained the power of phosphorescing under heat after some hours in darkness. It required two or three days to completely regain the power. The substances which phosphoresced at ordinary temperatures lost their phosphorescence when placed on the hot plate but rephosphoresced on cooling, and this cycle could be repeated indefinitely. The author attributes these phenomena to a series of chemical reactions which take place at different temperatures. He has experimented with other phosphorescent bodies in which the chemical changes are known, to obtain support for this hypothesis. J. B. H.

REFERENCES.

1265. *Reference Points in Spectra.* **A. Perot** and **C. Fabry.** (Comptes Rendus, 130. pp. 492–495, Feb. 19, 1900.)—In continuation of their former work the authors have determined by their interferential spectrometer a series of standard wave-lengths from λ 4,300 to λ 6,700. The present paper also describes a recent improvement for more accurately gauging the distance between the interfering surfaces, and contains a list of eighteen standard lines in the spectra of mercury, zinc, copper, silver, sodium, and lithium. C. P. B.

1266. *Energy in Spectrum of a Black Body.* **F. Paschen.** (Preuss. Akad. Wiss. Berlin, S.ber. 53. pp. 959–976, 1899.)—In previous articles (see 1899, Abstracts Nos. 1348, 1482) the author has investigated the distribution of energy in the spectrum of a black body at temperatures from 100° to 450° C. The present article contains description of apparatus and experimental data extending the inquiry to about 1,300° C. C. P. B.

1267. *Propagation of Light.* **G. Sagnac.** (Journ. de Physique, 9. pp. 177–189, April, 1900).—An article dealing at length with the subjects referred to in Abstracts Nos. 48 and 614 (1900).

HEAT.

1268. *High Temperature Thermometer of Quartz.* **A. Dufour.** (Comptes Rendus, 130. pp. 775–776, March 19, 1900.)—The author describes a thermometer consisting of a quartz tube and bulb containing tin; temperatures between 240° and 580° can be measured with it. T. H. P.

1269. *Simple Apparatus for Expansion of Air.* **C. F. Adams.** (Phys. Rev. 10. pp. 178–179, March, 1900.)—This apparatus is designed to facilitate the attainment by elementary students of a good determination of the expansion coefficient of air at constant pressure. It consists of a glass U-tube of 3 or 4 mm. bore. The limb which contains the air is about 30 cm. long, and is closed at the end by a piece of glass fused into it. The other limb is about 50 cm. long and open at the end. The bend of the tube contains sulphuric acid to a depth of about 10 cm. Another glass tube is slid into the longer limb of the U-tube and dips into the acid. This tube serves as a plunger, and is used to adjust the level of the acid to the same height in each limb as ascertained by a sliding cross-piece. Temperatures between 10° and 50° C. are used in the experiments. Within these limits the vapour pressure of the acid is negligible and the use of acid instead of mercury insures the dryness of the air under examination. The U-tube is placed successively in water baths of various temperatures, the plunger and cross-piece being each time adjusted and the measurement of volume made on withdrawal from the bath. The significant figures of the results obtained by one class of students are as follows: 363, 364, 369, 368, 364, 371, 351, 366. E. H. B.

1270. *Fusion of Rubidium.* **M. Eckardt.** (Ann. d. Physik, 1. 4. pp. 790–792, April, 1900.)—Large quantities of rubidium and cæsium were prepared by a new process, and their change of volume during fusion was determined by means of a special paraffin dilatometer securing perfect protection against oxidation. The fusing-point of rubidium was found to be 37·80°. On melting, 1 gramme of rubidium was found to increase in volume by 0·01657 c.c. The corresponding expansion of cæsium was 0·01398 c.c. E. E. F.

1271. *Bunsen's Ice-Calorimeter.* **J. W. Mellor.** (Journ. Phys. Chem. 4. pp. 135–136, Feb., 1900.)—In order to exclude all air from the water-chamber, fill the chamber a third full with distilled water, attach the side tube of the calorimeter to a tube passing through the cork, and nearly to the bottom, of an ordinary distilling flask half filled with distilled water, the side neck of which is fitted to one end of a Liebig's condenser whose other end is connected to a water air-pump. Set the pump in action and heat both calorimeter and flask until the latter gives the characteristic "hammering" when shaken: the calorimeter will then become filled with air-free water on removing the flame that heats it. R. E. B.

1272. *New Thermo-Calorimeter.* **G. Massol.** (Comptes Rendus, 130. pp. 1126–1128, April 23, 1900.)—For the investigation of the specific heats of superfused bodies and of very concentrated saline solutions near their fusing-

and boiling-points Regnault's thermo-calorimeter is especially adapted, but its range is very limited. The author, therefore, provides an extra chamber at the top of the measuring-tube, as in Walferdin's thermometers, so that varying amounts of the measuring liquid may be employed; he replaces alcohol by sulphuric acid so that he may operate up to 300° C. instead of being limited to 50°, and instead of a cooling chamber surrounded by ice he employs any suitable constant-temperature stove. R. E. B.

1273. *Isothermals of Gaseous Mixtures.* **N. Quint.** (Phys. Zeitschr. 1. pp. 65–66, 1899. Communication from the Physical Laboratory of the University of Amsterdam.)—To test van der Waals' theory of the mixture of two bodies, mixtures of ethane and hydrochloric acid were examined, and the two gases were also examined separately. Among the results obtained it appears that the critical temperature of the mixture examined is 27·2°. Although, therefore, the critical temperatures of the pure substances are separated by some 20 degrees, the critical temperature of the mixture is found to be outside those of the two constituents. This result, which confirms similar results previously obtained, is in direct contradiction to Pawlewski's rule. E. E. F.

1274. *Thermo-dynamical Properties of Superheated Steam.* **J. H. Grindley.** (Roy. Soc., Proc. 66. pp. 79–85, March 8, 1900.)—In experiments on wire-drawing saturated steam the law of adiabatic expansion is assumed to hold during the flow, and is used in obtaining temperature results from wire-drawing calorimeters for the determination of the initial dryness of steam. If the assumption is correct, it appears, from the theory, that when the ratio of the lower to the higher pressure on opposite sides of the orifice is diminished below a certain value, the higher pressure being constant, the rate of discharge of the steam should be constant. For saturated steam this ratio is 0·5824. If the flow of steam be truly adiabatic this ratio giving maximum flow should be actually found by experiment; if some other value be found, the law of flow is not adiabatic. An experiment was made with an orifice drilled in a piece of thin brass, when it was found that the maximum discharge did not occur until the pressure ratio had fallen to 0·333—a value far below that indicating adiabatic flow. A later experiment was made with an orifice drilled in a glass plate, the experimental results showing a complete agreement with the theory of adiabatic flow.

Experiments were conducted with saturated steam at a known pressure and temperature in the steam chest, but at different degrees of wetness in different experiments. The maximum difference of temperature at any particular pressure in the wiredrawn steam which could be found to exist between experiments with different degrees of wetness was 0·35° F. Generally the difference could not be distinguished; if the dryness of the steam before passing the orifice had been altered by so little as 0·06 per cent., a difference of 1° F. should have been observed in the temperature of the wiredrawn steam. Between the limits of temperature obtained by wire-drawing saturated steam at temperatures varying from 240° to 380° F., the condition of a perfect gas was not obtained, even when the wiredrawing was continued to 3 or 4 lbs. per square inch absolute pressure. Between the same temperatures, and between pressures of 2·5 and 195 lbs. per square inch, the specific heat at constant pressure was found to increase with temperature, the mean specific heat at atmospheric pressure between the temperatures 230° and 246° being 0.4317, and between the temperatures 295° and 311° the mean specific heat was 0.6482. The variation in the specific heat with the pressure is very small compared with the variation with temperature.

The specific heat K_p and the cooling effect $\partial\theta/\partial p$ or c are considered. The cooling effect c is found to be inversely proportional to $\tau^{3\cdot 6}$, where τ is the absolute temperature. It is then shown that the formula $\frac{\partial}{\partial p}(K_p) = -\frac{\partial}{\partial \tau}(c\,K_p)$ is capable of strict proof. A. S.

1275. *Otto Gas Engines.* **L. Marchis.** (Comptes Rendus, 130. pp. 705–708, March 12, 1900.) *Theoretical Cycle of a Gas Engine.* **A. Witz.** (Comptes Rendus, 130. pp. 1118–1119, April 23, 1900.) *Gas Engines.* **L. Marchis.** (Comptes Rendus, 130. pp. 1246–1248, May 7, 1900.)—The efficiency is calculated for a series of operations not perfectly cyclical, which is really as follows, though in the paper described with less exactness: (1) The explosive mixture is admitted to the cylinder, as it alters volume from 0 to V, at the temperature t and at the pressure p of the atmosphere, which also acts on the outer face of the piston; (2) it is then compressed adiabatically to volume v, attaining thereby the pressure P and temperature T; (3) explosion then occurs adiabatically and isometrically, the pressure and temperature becoming P′ and T′; (4) adiabatic expansion to volume V follows, with fall of pressure and temperature to p' and t'; (5) isometric change till the pressure becomes p next occurs, and (6) the exploded mixture is finally allowed to escape into the atmosphere, the volume of the cylinder being diminished to 0, while the outer face of the piston is again exposed to atmospheric pressure. Operations (2) and (4) at once give $A = k'(T' - t') - k(T - t)$ for the area of the cycle, where k and k' are the isometric specific heats of the mixture before and after explosion, and from operation (3) we have $k'(T' - T) = H$, where H is the heat given out on isometric explosion at T. The efficiency is then A/H [which, expressed in terms of the data, is

$$1 - a^{\kappa'-1} + \{k'(1 - a^{\kappa'-1}) - k(1 - a^{\kappa-1})\}\,T/H,$$

where $a = v/V$ and $T = ta^{1-\kappa}$, κ and κ' being the ratios of the isopiestic and isometric specific heats of the mixture before and after explosion], and, if we may take κ' and κ as approximately equal, and so $k' = k$, this becomes $1 - (t' - t)/(T' - T)$ [which is independent of H and equal to $1 - a^{\kappa-1}$]. Starting from this result Marchis adversely criticises the usual theory given for the Otto engine, in which he asserts that the assumption $p' = p$ is made. [The above notation is varied from that of the paper for greater symmetry.]

Witz denies that the assumption $p' = p$ is made, and states that in the usual theory operation (4) proceeds till the pressure falls to p (the temperature then being t'' and the volume V″), and that (6) follows, the efficiency then for $k' = k$ becoming $1 - \kappa(t'' - t)/(T' - T)$. [But this value requires the work done to be $k'(T' - t'') - k(T - t) - p(V'' - V)$; does not however condition (6) require the omission of the last of these terms, and give $1 - (t'' - t)/(T' - T)$ for the efficiency ?]

Marchis points out that Witz's criticism is off the point, as he considered engines of the Otto type only in which the adiabatic expansions and compressions are not different; that there is nothing like a true cycle in the case of gas engines, and that Witz's formula for the efficiency cannot be general, though given as such. R. E. B.

ELECTRICITY.

THEORY AND ELECTROSTATICS.

1276. *Electron Theory of Metals.* **P. Drude.** (Ann. d. Physik, 1. 3. pp. 566–618, March, 1900.)—The author uses the term "ion" for the combination of electric particles and ponderable masses found in electrolytes, and he calls the particles probably concerned in metallic conduction "electrons" or "electric nuclei." He leaves it undecided whether an electron carries any ponderable mass along with it. It is not necessary to attribute ponderable mass to an electron in order to be able to attribute kinetic energy to its motion, and a certain inertia, as exhibited in the magnetic deviation of kathode rays and the optical qualities of metals. Since every moving electron represents an electric current, producing a certain number of magnetic lines of force in the surrounding ether, all forces tending to alter the direction and velocity of an electron must call forth opposing forces due to a change in the number of magnetic lines of force attached to the electron, or, in other words, due to the self-induction of the electron. Since the self-induction of a current of given strength is the greater the smaller the section in which it is concentrated, the apparent mass of an electron must depend upon its charge and upon its dimensions. The absence of a ponderable mass attached to the electron makes it possible to bring metallic and electrolytic conduction under the same theory. The assumption that the ratios of charge to mass in the positive and negative electrons respectively are two absolute constants in all metals is not in agreement with the optical behaviour of the latter. In gold and copper it is necessary to assume the presence of bound electrons, having a certain position of equilibrium in the body, and bound to the material particles. It is these bound electrons which play a part in optical processes. The author's theory differs from that of Riecke in the smaller number of unproved hypotheses, based as it is upon the laws of gases. Loschmidt's value for the number of molecules in 1 c.c. of a gas, and Thomson's value for the charge of an electron.

The author assumes the existence of any number of different kinds of electrons with various charges, each charge being, however, a multiple of a certain elementary charge. These freely movable electrons or "nuclei" are assumed to obey the kinetic theory of gases. That positive and negative nuclei do not coalesce to a neutral point, in spite of their mutual attraction, is attributed to their high kinetic energy, as in the case of a comet which never returns to the solar system. The ponderable atoms of a solid may also possess kinetic energy, but are bound to certain positions of equilibrium. Exceptions from Wiedemann's law of conductivities occur wherever the number of nuclei depends upon the temperature. From the deviation of a metal from that law the ratio of the conductivities of its two types of nuclei may be calculated. The author investigates the phenomena of contact electricity and thermoelectricity, both in liquids and solids, with the aid of his theory, and arrives at the conclusion that all galvano- and thermo-magnetic effects may be explained and calculated with its aid, as he intends to show in detail in two further communications. E. E. F.

1277. *Relation between Magnetic Field and Permeability.* **R. A. Fessenden.** (Phys. Rev. 10. pp. 1–33, Jan., and 83–115, Feb., 1900.)—In connection with his determination of the nature of the electromagnetic quantities the author was led to investigate the various suggested relations between μ and H, in the hope of thus finding the needed fourth equation [see 1900, Abstract No. 1278]. The relation proposed by Lamont and Frölich is—

$$1/\mu = a + b\,\mathrm{H}.$$

Kennelly's formula, proposed October, 1891, is—

$$1/(\mu - 1) = a + b\,\mathrm{H} = \nu_i.$$

The first is obviously incorrect for high values of induction, as it makes the total induction reach a limit, and Ewing's experiments show this is not the case. Kennelly's formula, on the other hand, has been confirmed by Steinmetz and again by the author in a research here detailed. The difference between the two is that Kennelly considers the induction contributed by the iron as separate and distinct from that contributed by the ether, in the same manner as, in Gladstone's law, we consider the refraction contributed by the matter as distinct from that contributed by the ether. There are thus two magnetic circuits in parallel: one, the intrinsic circuit, carrying a flux numerically equal to B — H; the other, the extrinsic circuit, carrying a flux numerically equal to H. As they both have the same difference of magnetic potential across them, the magnetic resistivity, or reluctivity, is, in the two cases, numerically $\mathrm{H}/(\mathrm{B} - \mathrm{H})$ and H/H. Kennelly's law means that this intrinsic reluctivity, ν_i is given by the formula $a + b\,\mathrm{H}$, or that this intrinsic reluctivity varies as the space rate of drop of magnetic potential varies. The papers of Kennelly and Steinmetz showed an experimental agreement with the formula fairly close in all cases examined. Still the formula had been put forward as a purely empirical one and not as the expression of any physical law. The present author accordingly subjected it to a searching test. For this purpose he objects to the current experimental methods, whether with long wires or rings of the ordinary form, and describes the elaborate precautions taken in his own research on soft iron. This obeyed the formula with a maximum deviation of ¼ per cent., which was the maximum amount of experimental error. On reviewing the work of Gerosa and Funzi, of Steinmetz and of Silow, on iron, on the *non-magnetic* 10 per cent. amalgam of iron with permeability as low as 2, and on solutions of chloride of iron respectively, it is concluded that it is extremely probable that the law holds generally and that the following statements are justified. The relation between H and ν_i is given for all substances by the equations—

$$\nu_i = a + b\,\mathrm{H}, \text{ or } d\mathrm{B}_i / d\mathrm{H} = a\mathrm{B}_i^2 / \mathrm{H}^2,$$

where—

$$\mathrm{B}_i = \mathrm{B} - \mathrm{H}.$$

The constant a is shown to have the nature of elasticity, and b is shown to have zero dimensions. Further—

$$\frac{b\eta}{a} \doteq 0{\cdot}007 \text{ approximately,}$$

where η is the hysteresis loss per c.c. per cycle.

[The remainder of this paper is dealt with in Abstracts Nos. 1233, 1234, 1235, 1278, and 1279 (1900).] E. H. B.

1278. *Nature of Electromagnetic Quantities.* **R. A. Fessenden.** (Phys. Rev. 10. pp. 1–33, Jan., and 83–115, Feb., 1900.)—Following up the work of Rücker (Phil. Mag., Feb., 1889) and Williams (Phil. Mag., Sept., 1892), the present author, by use of dimensional formulæ, determines the nature or quality, of quantity of electricity, quantity of magnetism, dielectric constant and magnetic permeability. Let these physical quantities be denoted respectively by Q, P, κ, and μ; then it had been shown by Williams that, on making certain very natural assumptions, there were only two possible solutions. Of these, one makes μ a density and κ the reciprocal of an elasticity, while the other interchanges the natures of these two quantities. It is here pointed out that this ambiguity remained because some time back only three independent phenomena were known connecting the four unknown quantities. The author's experiments and his examination of the results of others have led him to formulate a fourth relation as follows: "For all magnetic substances the rate of variation of magnetisation with magnetising force is proportional to the square of the magnetic susceptibility." This relation is based on an equation originally proposed by Kennelly in 1891. The suggestion to search for a new relation between μ and H was derived from consideration of the three relations previously known, which may be expressed thus:—

$$Q/P = \kappa^{\frac{1}{2}}/\mu^{\frac{1}{2}} \qquad (1)$$
$$QP = ML^{2}/T \qquad (2)$$
$$\kappa^{\frac{1}{2}}\mu^{\frac{1}{2}} = T/L \qquad (3)$$

Of these three equations (1) is derived from Coulomb's law and its magnetic analogue; (2) is from Faraday's law, that the time rate of change of induction is a measure of the voltage, voltage multiplied by current giving power; while (3) is from Weber's law, that a circuit carrying a current is equivalent in its magnetic effect to a magnetic shell whose moment is equal to the area enclosed by the contour of the circuit. This third equation is known as Maxwell's.

A fourth relation was then written as follows:—

$$\kappa^{\frac{1}{2}}/\mu^{\frac{1}{2}} = Z \qquad (4)$$

and different dimensional values assigned to Z and the consequences discussed. Williams's result is then reached that either κ is a density and μ a compliancy, or *vice versâ.* The critical relation is then inferred, viz., "*Of κ and μ, the one which is a compliancy will be an inverse function of the corresponding force.*" This is the touchstone. It is known that the capacity of a condenser does not decrease with increased voltage, and equally well known that the *permeance* of a magnetic circuit does decrease with increase of *gilbertance* [*i.e.*, μ is known to decrease with increase of H]. It then remained to be proved that the rate of this change is that called for by the statement enunciated above. This being done, Z is shown to have the dimensions $M/L^{2}T$. On substitution of this value in (4) the solution follows, namely, that—

$$Q = M/T, \quad P = L^{2}, \quad \kappa = M/L^{3}, \quad \mu = LT^{2}/M.$$

Or in words, *the dielectric constant is of the nature density and the magnetic permeability is the reciprocal of an elasticity.* The author then adduces much corroborative evidence and discusses many incidental matters.

[The remainder of this paper is dealt with in Abstracts Nos. 1233, 1234, 1235, 1277, and 1279 (1900).] E. H. B.

1279. *Removal of 4π from Magnetic Equations.* **R. A. Fessenden.** (Phys. Rev. 10. pp. 1–83, Jan., and 83–115, Feb., 1900.)—The author discusses the removal of 4π without a change in the legal units [see also Abstract No. 643 (1900)]. The following changes are introduced. The unit quantity of magnetism is made equal to the present magnetic line, and the unit difference of magnetic potential to the ampere turn. No change is made in the coulomb, ampere, volt, ohm, farad, joule, or watt. Unit quantity of magnetism is thus made $1/4\pi$ times as large as before. Difference of magnetic potential is made 4π times as large as before. In place of dielectric constant and permeability the somewhat different quantities *capity* and *permity* are suggested. The permity of a vacuum would then be 4π, whereas the permeability for vacuo is now unity. The value of the dielectric constant would remain the same as before, only as we should be dealing with a different thing, viz., the ratio of quantity to potential gradient instead of flux to potential gradient, we should speak of the capity of a vacuum as being $1/4\pi$, where before we spoke of the dielectric constant of a vacuum as unity. On the new system there is no use for "flux" as distinct from "quantity." This, it is claimed, simplifies matters by rendering unnecessary 46 quantities now in use.

[Other parts of this paper are dealt with in Abstracts Nos. 1233, 1234, 1235, 1277, and 1278 (1900).] E. H. B.

1280. *Rotations in an Electrostatic Field.* **L. Graetz.** (Ann. d. Physik, 1. 3. pp. 530–541, March, 1900.)—The author produces Quincke's rotations in a constant electric field, not by suspending bodies in it, but by mounting spheres of sulphur, ebonite, or paraffin on a needle-point, so that they are capable of continuous rotation. Experiments made in this manner show that the explanation of these rotations on the hypothesis of a repulsion of the charged portions of the rotating body by the similarly charged electrodes applies not only qualitatively but quantitatively. Hence the rate of rotation may serve the purpose of determining the conductivity of very bad conductors and its variation under varying conditions. The author applied this method to the measurement of the conductivity of air ionised by Röntgen rays, and he found that in liquids also, like benzol and ether, an increase of conductivity due to the rays could be traced. E. E. F.

1281. *Dissipation of an Electric Charge in Air.* **J. Elster** and **H. Geitel.** (Phys. Zeitschr. 1. pp. 11–14, 1899.)—The presence of certain bodies, such as a piece of slowly oxidising phosphorus, is known to impart to ordinary air a certain electric conductivity. Röntgen and Becquerel rays possess the same property; but it has not been established experimentally whether ordinary air in the open possesses an electric conductivity or not. The object of this investigation was to answer this question.

Suppose a charged body, placed in the open air, had its potential indicated on an electrometer. The loss of potential in a certain time when the body is connected to the electrometer gives a measure of the dissipation of charge provided we know the corrections to be applied for leakage, &c.

The electrometer used is a gold-leaf electroscope of special construction. The leaves are supported on a metal pillar fixed to ebonite insulation at the bottom of the glass case. This metal pillar carries a ball at its upper end which is bored out conically on the top to receive the end of the support for the electrified body, so that the body is entirely supported by the electrometer. The glass case has a hole in the top which clears the support.

The electrified body consists of a hollow metal cylinder with closed ends supported on a metal rod coaxial with the cylinder. The free end of this rod is turned to fit the conical hole in the top of the electrometer pillar.

The experimental readings taken are: first, the rate of fall of potential (or collapse of the leaves) with the cylinder in position; second, the rate of fall of potential without the cylinder; and third, the ratio of the capacity of the electroscope alone to the capacity of the electroscope and cylinder together. This last is obtained by charging the electroscope alone, then by means of an insulated handle placing the cylinder in position on the electroscope and noting the immediate fall of potential. Suppose in the first experiment the potential falls from V_0 to V_1 in time t, and in the second it falls from V'_0 to V' in time t'; then the electricity lost by the cylinder during the experiment is given by—

$$e = \frac{1}{t}\log\frac{V_0}{V_1} - \frac{n}{t'}\log\frac{V'_0}{V'}$$

where n is the ratio of the capacities.

The results of the experiments the authors propose to give in another paper. The dissipation is not always the same, but alters with the meteorological conditions and also with the sign of electrification. At mountain-tops in clear weather the loss of negative is much greater than the loss of positive. In cloudy weather both sink to a minimum. In the neighbourhood of waterfalls positive is dissipated more quickly than negative. The results agree with the assumption that ordinary air contains equal numbers of positively and negatively electrified particles. The negatively electrified particles would slowly discharge a positively electrified body, and *vice versâ*. At mountain-tops the density of the earth's negative charge is greatest, and so there is a preponderance of positively electrified particles in the air which account for the increased rate of discharge of negative electricity. In the neighbourhood of waterfalls the conditions are reversed. In cloudy weather the condenser action of the clouds alters the conditions.

The loss in ten minutes in a room of 65 cubic metres capacity was doubled as soon as 300 grammes of Uranium-pitch was brought into the room to a distance of 2 or 3 m. from the cylinder. A draught from the neighbouring room containing the so-called Radium and Polonium preparations produces remarkable increase in the dissipation of the charge. J. B. H.

1282. *Electrical Effects on Evaporation of Sodium in Air and other Gases.* **W. C. Henderson.** (Roy. Soc., Proc. 66. pp. 183–186, April 4, 1900.)—The experiments made on the evaporation of fused sodium lead to the conclusion that no electrification can be detected unless oxidation is going on. Thus electrification was detected before fusion of the sodium if air was present, but not detected at all when coal-gas was present to the exclusion of the air. E. H. B.

DISCHARGE AND OSCILLATIONS.

1283. *Gas Currents in Incandescent Lamps.* **J. Stark.** (Elektrotechn. Zeitschr. 21. pp. 151–152, Feb. 22, 1900.)—The author discusses the various theories advanced to account for the deposit of carbon on the inner walls of incandescent lamps in the course of time. Moissan's hypothesis of a slow evaporation of the carbon of the filament is placed in doubt by the fact that the deposit does not depend upon the degree of exhaustion. Berliner's idea that gases are occluded in the filament and escape with explosive rapidity as soon as incandescence sets in is invalidated by the observation that the deposit is the same in continuously glowing lamps and in those which are often relighted. The author attributes the disintegration of the carbon to vagrant currents between various parts of the carbon filament, which traverse the intervening gas as in a Crookes tube. These vagrant currents can be placed in evidence by probes, but they are often made evident to the eye by an "aureole" between the arms of the filament which is nothing but the positive glow of a gaseous discharge. The internal currents are the stronger the greater the difference of potential between successive portions of the filament —*i.e.*, the higher the voltage of the circuit. The disintegration of the carbon is strongest at the kathode part, which turns rough very soon and wears through quickly where continuous currents are used. E. E. F.

1284. *Influence of Iron Cores on Condenser Discharges.* **G. A. Hemsalech.** (Comptes Rendus, 130. pp. 898–900, April 2, 1900.)—In the outer circuit of a condenser a self-induction is inserted, together with a vacuum and a spark-gap. The condenser is connected in parallel with an induction coil and a Wimshurst machine. The resulting discharge is of an oscillating character, and the polarity of the electrodes in the vacuum tube cannot be distinguished owing to the rapidity of the reversals. Its aspect is not changed by reversing the induction coil. If now an iron core is gradually introduced into the inductance coil, the oscillations are diminished and finally disappear. The process is clearly indicated by the aspect of the vacuum tube. The poles are gradually differentiated and establish themselves definitely at each end of the tube. This polarity is reversed by reversing the induction coil. The same transformation of the discharge may be brought about by inserting a water resistance. E. E. F.

1285. *Spark Potentials.* **J. E. Almy.** (Ann. d. Physik, 1. 3. pp. 508–529, March, 1900.)—The author determines the variation of spark potentials with the distance in various solid and liquid dielectrics, including glass, mica, quartz, paraffin, ebonite, turpentine, petroleum, xylol, and benzol. In all these substances the electric strength decreases with increasing thickness. The spark potential required for piercing 1 mm. of each of these substances is: Glass, 83·5; mica, 1890; paraffin, 375; turpentine, 161; petroleum, 212; xylol, 174; benzol, 194 c.g.s. units. The last figure is, however, doubtful. E. E. F.

1286. *Electric Arc between Metals.* **L. Arons.** (Ann. d. Physik, 1. 4. pp. 700–718, April, 1900.)—For the study of the electric arc as influenced by the nature of the surrounding gas, metallic electrodes are to be preferred to carbon electrodes, as their composition is better defined and they do not give out the great quantities of strange gases which render experiments in different gases worthless in the case of carbon electrodes. The gases experimented with were nitrogen and hydrogen. In nitrogen, arcs were obtained between aluminium, cadmium, copper, iron, magnesium, platinum, and brass electrodes. Tin melted at once, and between silver electrodes no arc could be made to play in an atmosphere of nitrogen. This fact is all the more remarkable as silver yields a particularly brilliant arc in air. It is evidently connected with the difference of chemical affinity between the metal and the gas in the two cases. The author found that nitrides are formed of all the other metals, but not of silver. Aluminium electrodes are covered with a greyish-black crust, whose chemical properties identify it with the nitride discovered by Mallet. Brass electrodes acquire a copper colour, owing to the greater consumption of zinc. Copper and aluminium, which in nitrogen give very beautiful arcs, give practically none in hydrogen. Platinum, silver, iron, and lead require very strong currents. The best hydrogen arcs are obtained with cadmium, zinc, and magnesium. E. E. F.

1287. *Electric Discharge in Gases and the Heat Produced.* **W. Wien.** (Phys. Zeitschr. 1. pp. 10–11, 1899.)—The electric discharge in gases takes place partly by means of material particles which, moving with great velocities, are accelerated at first positively, then, by impacts against other particles, negatively. These conditions must give rise to a radiation of electromagnetic energy. The present investigation was undertaken to see whether this energy could be measured by the difference between the electric energy supplied to vacuum tubes and the heat produced in the tubes. The E.M.F. at the electrodes and the current were measured by volt and ampere meters, and the heat produced was measured by a Bunsen calorimeter. The following table, in which some of the results are reproduced, shows that within the limits of experimental error the electrical and heat energy are equal :—

E.M.F. volts.	Current amperes × 10^6.	Calories × 10^3 calculated.	Calories × 10^3 observed.
368	1,085	95·4	94·9
535	1,152	147	149
562	5,682	763	771
682	4,394	716	713
838	2,026	406	411
932	1,731	385	393
1,650	310	122	125

J. B. H.

1288. *Magnetisation of Vacuum Tubes.* **R. Dongier.** (Comptes Rendus, 130. pp. 650–653, March 5, 1900.)—The author compares the new magneto-optic effect observed by him [see 1900, Abstract No. 826] with that observed by Egoroff and Georgiewsky in the case of flame spectra. The former differs according to the angle between the ray and the magnet vector. E. E. F.

1289. *Magnetic Effect on Vacuum Tubes.* **N. Egoroff** and **N. Georgiewsky.** (Comptes Rendus, 130. pp. 900–901, April 2, 1900.)—In vacuum tubes containing hydrogen, helium, or iodine, placed vertically in an equatorial plane between the poles of an electromagnet, a partial polarisation of the emitted rays is only observed in one direction of the field, but not when the field is reversed. Partial polarisation is also observed in an axial direction along the tube, and then it is independent of the direction of the field. The polarisation phenomena are such as can be explained by the reflection and refraction of the glass walls of the tube, and the magnetic effect upon the polarisation is secondary, being due to the bending of the discharge under the influence of the magnetisation, which leads to modified optical conditions. The phenomena are the same in the case of a small flame burning in a similar tube. E. E. F.

1290. *Electrolytic Convection in Vacuum Tubes.* **H. Morris-Airey.** (Phil. Mag. 49. pp. 307–309, March, 1900.)—J. J. Thomson has described a case of apparent electrolytic convection of chlorine through hydrogen. A small quantity of chlorine is introduced into a capillary tube filled with hydrogen at a low pressure, and a discharge from an induction coil is sent through the tube. On examining the tube with a spectroscope the chlorine is seen only at the anode, and on reversing the current the chlorine appears at the new anode, and so on as often as the current is reversed. The most obvious explanation lies in electrolytic convection, but it is not at all certain that the chlorine does not pervade the whole tube, and is only discovered at the anode on account of the high temperature which exists there. To decide between the two views, the author attached two vacuum tubes to each other, end to end, and first used the anode of the one and the kathode of the other as electrodes, neglecting the two electrodes in the middle. If the electrolytic convection hypothesis were correct, a spectroscopic examination should reveal the existence of chlorine only in that tube whose extreme electrode was used as an anode. On separating the two tubes, however, the author found that the chlorine lines had the same intensity in both. E. E. F.

1291. *Electrolytic Convection in Vacuum Tubes.* **J. J. Thomson.** (Phil. Mag. 49. p. 404, April, 1900.)—The author does not think that Morris-Airey's "crucial" experiment [see preceding Abstract] disposes of his theory of electrolytic convection in vacuum tubes. That chlorine should be found in all parts of the tube is inevitable when as large amounts of chlorine are mixed with the hydrogen as in Morris-Airey's experiment. The increase of the partial pressure of the chlorine must accelerate its diffusion throughout the tube. In the author's original experiment a very small quantity of chlorine was mixed with the hydrogen, and the effects observed were not merely the presence of the chlorine lines at the anode and their absence at the kathode when the current was steady, but it was found that on reversing the current, so that the old anode became the kathode, the chlorine lines at first flashed out brightly at the new *kathode* and were faint at the anode. Then there was a short interval, during which they were faint at both electrodes, and finally they became bright at the new anode and invisible at the kathode. This seems a very complete proof of the transport of chlorine to the anode, and of the electrolysis of gases in a vacuum tube. E. E. F.

1292. *Electric Discharge through Argon and Helium.* **R. J. Strutt.** (Phil. Mag. 49. pp. 293–307, March, 1900.)—The difference of potential between the surface of the kathode and the outside of the negative glow is a constant, independent of the current and the pressure, provided there is no chemical action on the kathode and the glow does not cover the whole of the kathode. This constant potential difference is known as the kathode fall of potential. The author has measured it in helium and argon. In ordinary gases it is 300 volts. In helium it is 226, while in argon it is 167 volts. The case of argon presents peculiar difficulties, inasmuch as the positive column insists on curling round the kathode—a phenomenon which does not seem to have been observed in any other gas. The difficulty was finally overcome by giving the kathode the shape of a disc which nearly filled up the cross-section of the tube. An interesting investigation was that of the conductivity of helium under the influence of Röntgen rays. Experiments in which the conductivity of air and helium respectively was brought to a maximum by strong Röntgen-ray ionisation showed that the rate at which ions are produced in helium is about half that at which they are produced in air. The expenditure of energy in this process is also less. The ions of all monatomic gases are probably split up into something smaller. E. E. F.

1293. ***Velocity of Electric Waves in Bitumen with and without Wires.*** **C. Gutton.** (Comptes Rendus, 130. pp. 894–897, April 2, 1900.)—Following a method analogous to that adopted for establishing the equality of velocities of free and guided electric waves in air [see Abstracts Nos. 1498 (1899), and 1077 (1900)], the author now finds that this equality holds when the electric waves with and without wires are propagated in bitumen. E. H. B.

1294. *Masses of Ions.* **J. J. Thomson.** (Phil. Mag. 48. pp. 547–567, Dec., 1899. Paper read before the British Association at Dover.)—This paper contains an account of measurements of *m/e* and *e* for the negative electrification dissipated by ultra-violet light, and also of *m/e* for the negative electrification produced by an incandescent carbon filament in an atmosphere of hydrogen. They lead to the result that the value of *m/e* in the case of ultra-violet light, and also in that of the carbon filament, is the same as for the kathode rays; and that in the case of ultra-violet light *e* is the same in magnitude as the charge carried by the hydrogen atom in the electrolysis of solutions. In this case, therefore, we have clear proof that the ions have a very much smaller mass than ordinary atoms, so that in the convection of negative electricity at low pressures we have something smaller even than the atom, something which involves the splitting up of the atom, inasmuch as we have taken from it a part, though only a small one, of its mass.

The method of determining the value of *m/e* for the ions carrying the negative electrification produced by the ultra-violet light is based upon the fact that the rate of escape of the negative electrification at low pressures is much diminished by magnetic force if the lines of magnetic force are at right angles to the lines of electric force. The charge on the ion produced by the action of ultra-violet light on a zinc plate was determined by the author's method of measuring the charge on the ions produced by the action of Röntgen rays on a gas.

The results suggest that the ionisation of a gas consists in the detachment from the atom of a negative ion, this negative ion being the same for all gases, while the mass of the ion is only a small fraction of the mass of an atom of hydrogen. This negative ion is not improbably the fundamental quantity in terms of which all electrical processes can be expressed. For its mass and its charge are invariable, independent both of the processes by which electrification is produced and of the gas from which the ions are set free. It thus possesses the characteristics of a fundamental conception in electricity. The author sketches an electrical theory of which this conception forms the basis. The atom is regarded as containing a large number of similar bodies, which he calls "corpuscles." The mass of a corpuscle is the mass of a negative ion in a gas at low pressure, *i.e.*, about 3×10^{-26} grammes. In the normal atom this assemblage of corpuscles forms a system which is electrically neutral. The electrification of a gas may be regarded as due to the splitting up of some of the atoms of the gas, resulting in the detachment of a corpuscle from some of the atoms. The remainder of the atom forms the positive ion, and is of course of much greater mass. An atom might be split up indefinitely but for the fact that each detachment of a corpuscle increases the free positive charge of the remainder, and so increases the force of cohesion. The mass of the negative ion is about 1/500th part of that of the hydrogen atom. E. E. F.

1295. *De-coherence of Carbon.* **T. Tommasina.** (Comptes Rendus, 130. pp. 904–905, 1900.)—The author has discovered a variety of carbon which, when used in a coherer, automatically loses its coherence as soon as the electric waves cease to impinge upon it. The carbon powder used is that of the microphones of the Swiss telephone stations. It is enclosed in a little box of ebonite and mica, and two German-silver wires lead into it, with their ends 1 mm. apart. The coherer thus constructed is introduced into a telephone box and inserted in the circuit of the telephone magnet. The impact of a wave is indicated by a tick in the telephone. Besides the automatic decoherence, the new apparatus has the advantage of greater durability on account of the stable nature of carbon. E. E. F.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1296. *Insulation Tests.* **W. E. Ayrton** and **T. Mather.** (Phil. Mag. 49. pp. 343–347, April, 1900.)—The guard-wire as originally arranged by W. A. Price was applied near the ends of the cable under test; it was intended to eliminate errors due to end leakage. The authors now use the guard-wire to eliminate leakages of all kinds from the leads. A concentric cable is employed as the lead, the "inner" conductor of which is connected to the conductor of the cable under test, while the "outer" acts as a continuous guard-wire. The "outer" is connected to some point between the battery and galvanometer. It is shown that the guard-wire principle can further be applied to determine whether a cable is faulty throughout, or whether it contains one or more faults in definite positions. Also, by employing two drums, faults in braided and other unsheathed cables can be localised by the use of a guard-wire. In making measurements with the guard-wire, it should be connected as near the braiding as is consistent with the condition that the resistance between the guard-wire and braiding is high compared to the battery resistance. The above remarks refer to the direct-deflection method, but the authors show that accuracy can also be obtained with the "loss of charge" method, by the use of a guard-wire. In this case the potential of the guard-wire is caused to fall at the same rate as that of the conductor of the cable under test, so that no electricity passes between them, and there is no surface leakage. R. A.

1297. *Dielectric Constant of Hydrogen Peroxide.* **H. T. Calvert.** (Ann. d. Physik, 1. 3. pp. 483–485, March, 1900.)—The dielectric constant of hydrogen peroxide is interesting to determine on account of Bruehl's speculation concerning the tetravalence of oxygen. The author employed an aqueous solution of the pure dioxide of density 1·144, and determined its dielectric constant by the method of electric waves. The constant found was 84·7 at 18°. Assuming the density of the pure dioxide to be 1·5, and the law of mixtures to hold good, the dielectric constant of pure H_2O_2 comes out as 92·8. It shows no anomalous absorption, and that circumstance, together with the fact that its dielectric constant is greater than that of water, is in agreement with the predictions of Bruehl, who expected an abnormally high dielectric constant on account of the existence of unsatisfied valencies. E. E. F.

1298. *Measurement of Capacity.* **R. Wachsmuth** and **K. Bergwitz.** (Phys. Zeitschr. 1. pp. 7–8, 1899.)—This paper gives an account of an attempt to measure capacity, using the double refraction of carbon disulphide when in an electric field. Two exactly equal condensers of two plates each are placed in carbon disulphide baths, and a beam of plane polarised light passed in succession between the plates of the two condensers. The two condensers are connected in parallel, and subjected to the same source of alternating

E.M.F. If the plane of polarisation makes 45° with the plates of each condenser, the plates of the one condenser being perpendicular to the plates of the other, then no rotation of the plane of polarisation takes place. If a small condenser is added to one side of the circuit, however, a difference of phase is introduced, and there is no longer darkness in the crossed Nichols. By introducing a variable capacity in the other branch, darkness can be again produced when the capacities are equalised. Such is the method here used. For small capacities up to 150 electrostatic units an accuracy of about 0·1 per cent. is obtained.

For large capacities a special method is necessary. The large capacity is introduced in the one branch as before, but with a small capacity in series with it. The capacity is then given by $C_x = C_v C_m / (C_v - C_m)$, where C_v is the capacity of the small condenser and C_m the balancing capacity. Since $C_v - C_m$ is always a small quantity, the variable condenser must be very accurate. Experiments gave a maximum difference of 10 per cent. between measurements of capacity by this method and by the ballistic. J. B. H.

1299. *Thermo-magnetic Currents.* **G. Moreau.** (Comptes Rendus, 130. pp. 412–414, Feb. 12, 1900.)—The relation—

$$K = \frac{\sigma c}{\rho}$$

established independently by Voigt and by the author between the coefficients of the Hall effect c and the Nernst effect K, the specific heat of electricity σ and the specific resistance ρ, required verification by the determination of all these constants in the same specimen. The author has made observations at different temperatures on iron, steel, cobalt, and nickel, all metals for which σ and ρ vary slightly under the influence of the magnetic field. In all these metals the above formula is verified for temperatures between 0° and 60°. In the case of cobalt, the ratio $\frac{c}{K}$ is not changed by tempering, though both K and c are altered considerably. As usual, the variations of K follow those of c, the Hall effect being the fundamental phenomenon. The latter is considerably influenced by the molecular condition of the plate, and is in fact due, as the author believes, to a deformation of the plate under the influence of the magnetic field. This would account for the great differences between the results of individual observers. E. E. F.

1300. *Electrolytic Conductivity and Internal Friction of Salt Solutions.* **P. Massoulier.** (Comptes Rendus, 130. pp. 773–775, March 19, 1900.) —The variations in electrical resistance and internal friction of copper sulphate solutions caused by replacing part of the aqueous solvent by glycerine are in the same direction and of the same order of magnitude, but not proportional. The conductivity depends not only on the internal friction but also on the degree of ionisation, which varies with the temperature and also with the nature of the solvent. T. H. P.

1301. *Resistance of Bismuth in Magnetic Field.* **W. Eichhorn.** (Phys. Zeitschr. 1. pp. 81–83, 1899.)—The author compares the resistance of bismuth in a constant and in a varying magnetic field with a view to discover the existence of hysteresis in the increase of resistance due to increase of field strength. A bismuth spiral connected in one arm of a Wheatstone bridge was mounted on a disc capable of rotation between the poles of an electromagnet. A second disc on the same axis completed the battery circuit for an instant during the passage of the bismuth between the poles; the two discs being relatively adjustable, contact could be made while the bismuth was entering the field or while leaving it.

Omitting details of the experiments and the corrections applied, the results are as follows :—

The bismuth while entering the field shows a less increase of resistance than in a constant field of the same average strength, but shows a greater increase while leaving the field.

With increasing velocity of rotation the resistance diminishes to a minimum value when the bismuth is entering the field, and increases to a maximum when leaving it.

The minimum value was reached in increasing the field from 0 to 8,900 lines in about 0·02 secs. The difference of increase of resistance amounted to about 2·5 per cent. The author considers that these results point to a time-lag of the variation of resistance after the field variation. G. H. B.

1302. *Condenser in Induction Coil.* **K. R. Johnson.** (Phil. Mag. 49. pp. 216–220, Feb., 1900.)—Referring to Mizuno's paper [see 1898, Abstract No. 1252] the author explains the results. If the condenser is inserted across the interrupter in the primary circuit, the extra current darts into the condenser; and if the maximum of the potential-difference in the condenser is very great, a spark takes place in the interrupter, and thus the oscillations in the circuit are diminished by the spark. If the capacity of the condenser is very large, the maximum of potential difference in the condenser and the interrupter is small and unable to make a spark. Thus, the efficiency of the induction-coil is greatly increased by increasing the capacity a little, so long as the discharge by spark at the interrupter diminishes; when the spark is entirely suppressed, the efficiency of the induction-coil is greatest and the secondary spark-length a maximum. The capacity of the primary condenser being further increased, the efficiency of the induction-coil is diminished, for the reason that the maximum potential difference in the condenser is diminished, and, of course, so is the intensity of the current. Mathematical developments and tables of calculated and observed values of spark-length are given. A. D.

1303. *Three-Phase Wattmeter Connections.* **R. Arno.** (Écl. Électr. 22. pp. 379–384, March 10, 1900. Paper read before the first Congress of Italian Electricians at Como, Sept. 19, 1899.)—A description of the different methods by which a wattmeter or watt-hour meter can be connected to measure the power of a symmetrically loaded three-phase circuit on inductive load. The power factor of the load can also be determined from wattmeter readings alone. By connecting the thin coil across the terminals of the circuit containing the main coil, the value of EC $\cos\phi$ is found. By connecting the thin coil across the other two terminals of the star, a value is obtained for $\sqrt{3}$ EC $\sin\phi$. Hence $\cos\phi$ can be calculated. L. B.

1304. *Wave-Current Generators.* **C. Heinke.** (Ann. d. Physik, 1. 2. pp. 326–351, Feb., and 3. pp. 441–461, March, 1900.)—The author distinguishes two classes of wave-currents. One type is due to periodically varying electromotive forces, the other to periodically varying resistances. The latter may be divided into mechanical, electrolytic, and gaseous resistances, the first two being usually described as interrupters. All wave-current generators of automatic character, *i.e.*, those actuated by the current itself, especially the electrolytic and gaseous ones, require an E.M.F. capable of yielding a certain "saturation current." A further increase of E.M.F. only influences the number of waves per unit of time, but not the practically constant saturation current, nor the density of the latter in the effective cross-section. E. E. F.

1305. *Influence of Temperature, Pressure, Used Solutions and Size of Anodes on Silver Voltameters.* **J. F. Merrill.** (Phys. Rev. 10. pp. 167-174, March, 1900.)—No change in the weight of silver deposited is produced by increasing the air pressure to 100 atmospheres. Further, if the solutions are previously boiled the weight of the deposit is the same at 0° and 90° C. If the electrolytic solutions have been much used, however, there is a marked increase in the weight of silver deposited, which may be as great as 0·17 per cent. The size of the anode has no influence on the deposit, but a slight increase in weight was found on comparing an old kathode-dish with dull surface, with a new, bright dish. T. M. L.

1306. *Wattmeter Correction for Alternating Currents.* **T. des Coudres.** (Phys. Zeitschr. 1. pp. 76-77, 1899.)—The correcting factor for a wattmeter is $\frac{1+\tan^2\phi}{1+\tan\theta\tan\phi}$, where θ is the lag in the circuit under measurement and ϕ is the lag in the shunt coil of the wattmeter. When, as is generally the case, θ is unknown, the correction cannot be applied.

The author proposes to shunt the main current winding of the wattmeter by an inductionless resistance of value R, such that $\frac{L_2}{R_2}=\frac{L_1}{R_1+R}$, where L_1, L_2, and R_1, R_2 are the self-induction coefficients and resistances of the main and shunt wattmeter coils respectively. The correcting factor then is $1/\cos^2\phi.\left(1-\tan\phi\frac{W_1}{2\pi nL_1}\right)$, or approximately $\frac{1}{\cos^2\phi}$. G. H. B.

1307. *Mirror Galvanometer.* **W. Thiermann.** (Elektrotechn. Zeitschr. 21. pp. 211-214, March 15, 1900.)—This instrument is a special form of potentiometer which is in use in the testing-room of the Electrotechnical Institute of the Hanover Hochschule for measuring pressures ranging from 750 down to 0·0007 V. It consists of a mirror galvanometer with telescope for reading the deflections, a dial resistance with eleven resistances, and a standard cell. The main feature of the instrument is the provision of means for adjusting the position of the scale. This is effected by mounting it on a carriage capable of being adjusted along two horizontal guide-rods by means of nut and leading screw, these guide-rods being mounted on a second carriage which is itself adjustable along two vertical guide-rods on a tripod stand, by means of another leading screw. C. K. F.

ALTERNATING CURRENTS AND MAGNETISM.

1308. *Capacity of Symmetrical Systems of Conductors when subjected to Polyphase P.D.'s.* **C. E. Guye.** (Comptes Rendus, 130. pp. 711-713, March 12, 1900.)—The capacity of a conductor is, by definition, the ratio of its charge to its potential when all the other conductors in the neighbourhood are at zero potential. If the potential of one or more of the neighbouring conductors is not zero, and is made to vary, then the ratio of the charge to the potential of the first conductor is no longer constant in the general case. But in the special case of a symmetrical system of conductors, consisting of a number of parallel cylindrical conductors symmetrically arranged round an axis and enclosed in a hollow cylindrical conducting sheath, and subjected to polyphase potentials (there being as many phases as there are conductors), the author shows that the ratio of the instantaneous charge to the instantaneous potential of any one conductor is constant. Hence the "capacity" of a conductor in such an armoured polyphase transmission line acquires a perfectly definite meaning, and this quantity if known enables us at once to calculate the "condenser" current. The same result will hold for an overhead system of symmetrically arranged conductors, provided the distances apart of the conductors are negligible in comparison with their distance from the earth's surface. A. H.

1309. *Foucault Currents due to very Rapid Oscillations.* **I. Klemenčič.** (Phys. Zeitschr. 1. pp. 83–84, 1899.)—A high-frequency alternating current was maintained in a solenoid by Leyden jars charged by an induction coil with Wehnelt interrupter. The heating due to Foucault currents was measured in the mercury bulbs of various thermometers, and in iron wires enclosed in alcohol thermometers. The heating was considerably greater in the smaller mercury bulbs and in the thinner wires, as might be expected from the skin-effect of the rapidly alternating current. G. H. B.

1310. *Carrying Strength of Electromagnets.* **Boy de la Tour.** (Ind. Élect. 9. pp. 10–12, Jan. 10, 1900.)—Consider an electromagnet and carry it through the following cycle of operations :—(1) Pass a current through the coils and let the maximum value of the current be $I_0 = \frac{E_0}{R}$. (2) Apply on the keeper a pull of F dynes so that the magnetic circuit is elongated by a small quantity *dl* in a small time *dt*. This produces an induced E.M.F. due to the diminution of the flux. (3) Short-circuit the windings so that the flux disappears. On applying an E.M.F. the rise of current in the coils is given by—

$$E_0 - N\frac{d\phi}{dt} = Ri,$$

where N is the number of turns on the magnet, ϕ the flux through the core, and i the instantaneous value of the current.

The energy of the magnetic field is given by the expression—

$$\int_0^\infty N\frac{d\phi}{dt} \cdot i\,dt = N\int_0^\infty i\,d\phi$$

On applying to the keeper a force F it is displaced parallel to itself through a distance *dl* in a time *dt*. During this interval of time there is induced an E.M.F., $N\frac{d\phi}{dt}$, and the flux Φ_0 is diminished by a quantity $d\phi$. The diminution of energy during this period is—

$$NI_0 d\phi - \frac{\Phi_0 - d\phi}{2} . N di.$$

The energy supplied by the external source is—

$$\left(E_0 - N\frac{d\phi}{dt}\right) I_0 dt.$$

Also the work done on the keeper is Fdl, and that dissipated in heat is—

$$I_0^2 R\,dl = E_0 I_0\,dl.$$

When the coil is short-circuited the energy returned to the source is—

$$N\int_0^{\Phi_0} i\,d\phi - NI_0\,d\phi + N\,\frac{\Phi_0 - d\phi}{2}\,di.$$

Equating the energy supplied to the magnet to that which it restores, we get—

$$N\int_0^{\Phi_0} i\,d\phi + \left(E_0 - N\,\frac{d\phi}{dl}\right) I_0\,dl + F\,dl$$

$$= E_0 I_0\,dl + N\int_0^{\Phi_0} i\,d\phi - NI_0\,d\phi + N\,\frac{\Phi_0 - d\phi}{2}\,di,$$

or—

$$F\,dl = N\,\frac{\Phi_0}{2}\,di.$$

But—

$$\Phi_1 = \Phi_0 - d\phi = 4\pi N\,di\,.\,\frac{S}{2dl}$$

where S is the cross-section of the magnet pole thus—

$$di = \frac{\Phi_0 - d\phi}{4\pi NS}\,.\,2dl,$$

therefore—

$$F\,dl = \frac{N\Phi_0\,(\Phi_0 - d\phi)}{4\pi NS}\,dl.$$

And putting $BS = \Phi_0$, where B is the induction, we finally obtain the result—

$$F = \frac{B^2 S}{4\pi}.$$

W. G. R.

1311. *Torsional Elasticity of Rods and Magnetisation.* **J. S. Stevens.** (Phys. Rev. 10. pp. 161–166, March, 1900.)—This is the continuation of a former paper [see 1900, Abstract No. 202] on the effect of magnetisation on the flexional elasticity of steel and iron rods. The magnetisation is a longitudinal one, and produced by surrounding the rod with a coil carrying a current. The conclusions arrived at from the experiments are: (1) Magnetisation of an iron or steel rod increases its torsional elasticity. (2) The effect is greater in iron than in steel rods of the same dimensions. (3) The increase in elasticity varies with the length of the rod.

Comparing these results with those of the experiments in flexional elasticity there is a distinct agreement. In the first place the modulus of elasticity is increased in each case when the rod is magnetised: the increments are fairly proportional to the magnetising forces, and they are inversely proportional to the magnitudes of the original stresses. E. C. R.

1312. *Change in Length of Soft Iron in Alternating Magnetic Fields.* **L. W. Austin.** (Phys. Rev. 10. pp. 180–186, March, 1900.)—Near the end of the core under examination hangs a glass fibre about 0·06 mm. in diameter. This fibre passes between two glass plates and carries a mirror. When the iron core elongates one glass plate is moved and this rolls the fibre, giving a deflection of the beam of light reflected from the mirror. The main observations were on a bundle of ten wires of soft Swedish iron each 27·5 cm. long and 1·4 mm. in diameter. The magnetising solenoid was 24 cm. long with 12 turns per cm. The dilatometer gave a magnification of about 127,000 times with the scale 360 cm. distant.

The chief results are as follows: (1) The general course of the change in length of soft iron in an alternating magnetic field is the same as in the direct field. (2) For all values of H from 25 to 375 the change in length of the soft iron specimen is less with an alternating than with a direct field. (3) The maximum elongation gradually becomes less as the frequency of the alternations is increased. E. H. B.

1313. *Diamagnetism of the Eye.* J. **Mooser.** (Phys. Zeitschr. 1. p. 75, 1899.)—The author finds that the lens of the eye is diamagnetic, and suggests that a magnetic treatment might flatten the lens and cure shortsightedness.

G. H. B.

1314. *Magnetism and Molecular Volume.* S. **Meyer.** (Ann. d. Physik, 1. 4. pp. 668–672, April, 1900.)—Previous work has shown that in some diamagnetic compounds the molecular magnetism shows a greater diamagnetic value than would correspond to the sum of the atomic magnetisms. This happens in every case where the combination is accompanied by any considerable expansion, as in the iodides of silver, mercury, and lead. This suggests that the converse might occur in the case of a contraction of volume, and for deciding this question the salts of copper, with their small susceptibilities, are specially fitted. Measurements made on a number of copper salts show that there is no fundamental difference between cupric and cuprous salts as supposed by Wiedemann, since both the sulphides are diamagnetic. But there is a very decided and regular influence of volume changes. Expansion emphasises the diamagnetic character of a substance, and contraction emphasises its paramagnetic character. The magnetic properties of the elements can therefore only be obtained from the elements themselves, or from compounds whose formation entails no change of volume. E. E. F.

1315. *Magnetic Susceptibilities of Vanadium and Samarium.* S. **Meyer.** (Ann. d. Physik, 1. 4. pp. 664–667, April, 1900.)—The magnetic susceptibility of vanadium chloride was measured by the author's method in which the dissolved substance is contained in a cylindrical tube suspended by one arm of a balance in a magnetic field. The value obtained for the magnetic susceptibility of VCl_3 is $1{\cdot}25 \times 10^{-6}$. This gives a value for the susceptibility of the element which ranges it in the series of metals of the iron group as follows:—

$$V : Ni : Cr : Fe' : Co : Fe : Mn = \tfrac{1}{2} : 2 : 2\tfrac{1}{2} : 3 : 4 : 5 : 6.$$

This relation is, however, only provisional, and may be invalidated by future measurements.

Samarium sulphate gives a susceptibility of $11{\cdot}2 \times 10^{-6}$ for Sa, a value which is in good agreement with the values derived from the oxide and nitrate. For gadolinium a higher value is obtained than that previously found. This may be due to the salt containing impurities of a substance of high magnetic susceptibility. This is made probable by Exner and Haschek's discovery that both samarium and gadolinium contain an unknown substance which is revealed by a large number of spectrum lines. The author has shown that there is an intimate connection between the prevalence of spectrum lines and strong magnetism. E. E. F.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1316. *Combinations of Carbon Disulphide with Gases under the Silent Discharge.* **Berthelot.** (Annal. Chim. Phys. 19. pp. 145–150, Feb., 1900.)—Under similar conditions to those referred to in Abstract No. 1109 (1900), CS_2 vapour unites readily with half its volume of hydrogen, yielding a yellow resinous product smelling like mercaptan, insoluble in ether and sparingly in CS_2, decomposed by cold potash to form a little sulphide. The formula $C_2H_2S_4$ corresponds to a persulphuretted oxalic acid, or a derivative of glyoxal, $C_2H_2O_2$. With weak tensions the CS_2 polymerises more rapidly than it combines with H. Nitrogen combines in the proportions of $4CS_2 : N_2$, argon in those of $34\ CS_2 : A_2$; the latter compound is decomposed, like ozone, by strong sparks. In the case of CO, 100 vols. of CS_2 with 60 of CO left after ten hours' action only 3·5 vols. of CO without any CO_2, and a yellow solid partly soluble in water; the filtrate contained an "oxysulphuretted" acid converted into sulphuric by boiling HNO_3. [*Cf.* Abstract No. 1050 (1899)].

S. R.

1317. *Action of Light and Silent Discharge.* **Berthelot.** (Annal. Chim. Phys. 19. pp. 150–154, Feb., 1900.)—When exposed in sealed tubes for three months at ordinary temperatures either to diffused light or to bright sunshine, pure benzene, either alone or in contact with hydrogen, argon, or mercury, undergoes no change. With oxygen there is a slow absorption and production of resinous polymerides.

Carbon disulphide is acted on by direct sunshine and by mercury, but not by diffused light, and does not combine under these conditions with H or argon.

On the other hand, when the apparatus described in Abstract 1109 (1900), was charged with a mixture of argon and CS_2 vapour, and its poles connected with a battery of Leclanché cells, without a coil, so that a difference of potential of 200 volts was maintained to the end, after three months in diffused light, although no argon had been absorbed, yet 60 per cent. of the CS_2 had been changed into yellow condensed products. S. R.

1318. *Distillation of Metals.* **G. W. A. Kahlbaum.** (Phys. Zeitschr. 1. pp. 62–64, and 67–69, 1899. Paper read before the Naturforscherversammlung zu München.)—This paper desoribes experiments on the distillation of elements in high vacua (up to 0·00005 mm. pressure for the distillation of gold, silver, copper, and iron at 1100° C.). Se, Te, K, Na, Li, Tl, Bi, Sb, Cd, Mg, Al, Ag, Cu, Au, Ni, Fe, Cr, Zn, and Zr, have all been distilled in this way, and 1 grm. of copper has been separated from 3 grms. of nickel by the fractional distillation of a German cupro-nickel 10-pfennig piece. W. G. M.

1319. *Emission and Absorption of Water-vapour by Colloidal Matter.* **P. Duhem.** (Journ. Phys. Chem. 4. pp. 65–122, Feb., 1900.)—In van Bemmelen's experiments on the hydration and desiccation of colloidal jellies, like gelatinous silica or colloidal ferric oxide, when placed in an atmosphere of water-vapour the effects are very complex. Considering them to be due to the absorption of water-vapour by a body being affected by hysteresis, the author investigates the phenomena of incipient dehydration by the simple method already devised [see Abstract No. 1228 (1898)] for hysteretic changes in general, obtaining an expression for the speed of hydration, account being taken of the variations of pressure that are both perceptible and imperceptible. Comparison of the consequences of this expression with van Bemmelen's results is satisfactory in every way. Special stress is laid on the need of considering what the author calls *the region of secular variations* for any particular time in question. When dehydration has reached an advanced stage new phenomena occur, the water-content being now not sufficient to characterise the state of the hydrated body; the author therefore investigates the conditions of equilibrium on the assumption that they involve another variable, as well as the hydration, which is subject to hysteresis, and finds that all the observations, which are otherwise explained by van Bemmelen, can be readily interpreted and classified by this theory. R. E. B.

1320. *Motion of Crystals in Solvents.* **K. Schaum.** (Phys. Zeitschr. 1. pp. 5–6, 1899. S.ber der Gesellschaft zur Beförderung der gesamten Naturwissenschaften zu Marburg, June 21, 1899.)—This paper deals with the motion of substances while dissolving, analogous to the well-known motion of camphor in water. The substances dealt with are mostly salts readily soluble in water and dilute acids, KCN, KNO_3, $AgNO_3$, KCl, $CaCl_2$, $KMnO_4$, $K_2Cr_2O_7$, Sugar, Hydroquinone, and Urea. The crystal is dropped on to the top of a layer of mercury covered by the solvent and the motion then observed. The motion is always greater in dilute acid than in water. The nature of the motion is very characteristic. The crystal generally moves at first in a zigzag path, which changes to a circular one, and finally it rotates very rapidly on its axis. There is no doubt that the phenomena are connected with the rate of solution. A crystal of $KMnO_4$ covered with paraffin at all except one point moved always in the opposite direction to the current of solution, and when two points diametrically opposite are bared the crystal rotates rapidly on its axis. The experiments show that the rate of motion depends on the rate of solution and on the surface tension of the mercury, anything which alters the latter also altering the rate of motion. J. B. H.

1321. *Formation and Transformation of Mixed Crystals of Mercuric Bromide and Iodide.* **W. Reinders.** (Zeitschr. Phys. Chem. 32. pp. 494–536, March 20, 1900.)—The theoretical conclusions of Roozeboom [see 1900, Abstracts Nos. 678 and 679] are applied to the case of mercuric bromide and iodide on similar lines to those adopted by van Eyk [see 1900, Abstract No. 680] in the study of thallium and potassium nitrates. At the melting-temperature mercuric iodide and bromide form a complete series of mixed crystals; the iodide melts at 255·4° and the bromide at 236·5°, whilst a minimum melting-point is reached in the case of a mixture containing 59 mols. per cent. of the bromide which melts at 216·1°; the mixture is thus of the third type (Roozeboom, *loc. cit*). The composition of the crystals which separate from a melt of known composition was determined for a number of cases, but in no case was there a difference of 2 per cent. in the composition of the solid and liquid phases.

Mercuric iodide exists in two modifications, a yellow rhombic form which is stable above 127°, and a red tetragonal modification which is stable below that temperature. The bromide is only known in one form, isomorphous with the yellow iodide; its transition-point evidently lies far below the atmospheric temperature. At the temperature of the melting-point the iodide and bromide form a complete series of isomorphous crystals. The transition-point of mercuric iodide is lowered by the addition of the bromide, and at the same time it is broadened into a transition interval. Thus above 127° only yellow crystals can exist, but at 50° mixtures containing less than 4·3 mols. per cent. of $HgBr_2$ are red, and mixtures containing more than 15·5 mols. per cent. are yellow, whilst mixtures containing between 4·3 and 15·5 mols. per cent. consist of an aggregate of red and yellow crystals, the colour being an intermediate tint between the yellow and red; the corresponding limits at 25° are 6·2 and 21·3 mols. per cent. of $HgBr_2$, and at 0° 8·6 and 33·0 mols. per cent.

The change from one modification to the other is in this case very gradual, and greatly increases the experimental difficulties, but the striking difference in colour between the two modifications makes the optical method of special value. T. M. L.

1322. *Formation and Transformation of Mixed Crystals of Sodium Nitrate with Potassium and with Silver Nitrates.* **D. J. Hissink.** (Zeitschr. Phys. Chem. 32. pp. 537–563, March 20, 1900. *Cf.* Roozeboom, Abstracts Nos. 678 and 679 (1900), van Eyk, Abstract No. 680 (1900), and the preceding Abstract.) —The melting-point curve for mixtures of sodium nitrate (m.p. 308°) and potassium nitrate (337°) has been plotted by Carveth (Journ. Phys. Chem., 2·209) and found to show a sharp break at the minimum melting-point (218°) of a mixture containing 49·3 mols. per cent. of $NaNO_3$; the mixture is thus of the fifth type (Roozeboom, *loc. cit.*). The composition of the crystals which separate from a melt of known composition has now been determined, and it is shown that at 218° there is a gap in the series of mixed crystals from 24 to 85 mols. per cent. KNO_3, mixtures of intermediate composition solidifying to an aggregate of both forms. The transition-point of potassium nitrate is lowered by the addition of sodium nitrate, and is broadened into a transition interval.

The melting-point curve of mixtures of sodium nitrate (308°) and silver nitrate (208·6°) is of the fourth type, rising continuously as the proportion of $NaNO_3$ increases, but showing a sharp break at 217·5°, the melting-point of a mixture containing 19·5 mols. per cent. of $NaNO_3$. In this case the crystals are always richer in $NaNO_3$ than the liquid from which they separate, but there is a gap in the series of mixed crystals from 26 to 38 mols. per cent. $NaNO_3$, although the two series of crystals on either side of the gap are isomorphous; this gap widens as the temperature falls and extends from 4·5 to 50 mols. per cent. at 138°, and from 1·6 to 64·4 mols. per cent. at 15°.

Sodium nitrate is only known in the hexagonal-rhombohedral system, but silver nitrate passes into the rhombic system below 159·8°; the transition-point falls to 138° on adding 4·5 mols. per cent. of $NaNO_3$, but cannot be lowered any further as a mixture containing a larger proportion of $NaNO_3$ solidifies to a conglomerate of the two series of rhombohedral crystals. Rhombic mixed crystals rich in $NaNO_3$ might be expected to appear at lower temperatures, but this could not be realised experimentally. T. M. L.

1323. *Freezing-Point of Water containing Hydrochloric Acid and Phenol.* **J. A. Emery** and **F. K. Cameron.** (Journ. Phys. Chem. 4. pp. 130–134, Feb., 1900.)—Freezing-points are given for solutions of phenol in water and in solutions of hydrochloric acid of various strengths up to N/2. The results show that the freezing-point of a saturated aqueous solution of phenol is −1·179°. The freezing-point curve for solutions of hydrochloric acid saturated with phenol is a straight line parallel to the hydrochloric-acid curve; the depression of the freezing-point of water by hydrogen chloride and phenol is hence an additive effect. T. H. P.

1324. *Melting-Point of Ethyl Formylphenylacetate.* **C. G. L. Wolf.** (Journ. Phys. Chem. 4. pp. 123–129, Feb., 1900.)—When heated above its melting-point, ethyl formylphenylacetate suffers partial change into a tautomeric liquid modification, the time taken to re-solidify depending on the extent of the change. As determined in the ordinary way, the melting-point is variable, but if carried out in sealed capillary tubes, heated in a bath carefully stirred, the lowest temperature at which fusion occurs is 50°, which is hence the stable triple point. If after partial tautomeric change is produced by heating, the mass be rapidly cooled to — 80° and then allowed to stand in the air, solidification is greatly accelerated, crystals appearing after twenty-four hours; this is due to the fact that tautomeric change is more rapid the greater the difference between the actual point of unstable equilibrium and that of true equilibrium. T. H. P.

1325. *Ionisation of Gases.* **W. Kaufmann.** (Phys. Zeitschr. 1. pp. 22–25, 1899. Paper read before the Göttinger Philosophischen Fakultät, Aug. 12, 1899.)—The author discusses the differences between the migration of ions in gases and liquids respectively, and summarises the work done for determining ionic velocities in gases. The essential difference between gases and liquids is that in the former any E.M.F., however small, generates a current, while in liquids a certain minimum E.M.F. is required. On the other hand, there is in gases a certain superior limit of current strength which is never exceeded, however high the E.M.F. employed. That such a saturation current has never been observed in a liquid is due to the very high rate of reaction in electrolytes. Yet it is possible that liquids may be found to exist which do not strictly obey Ohm's law. The values obtained by Rutherford for the sums of velocities of ions in various gases show that approximately the mobility of the ions is inversely proportional to the square root of the molecular weight. The only exception to this rule so far observed is that of sulphurous anhydride, where the mobility has half the theoretical value.

E. E. F.

1326. *Taste and Degree of Dissociation of Acid Salts.* **L. Kahlenberg.** (Journ. Phys. Chem. 4. pp. 33–37, Jan., 1900.)—It has been shown by Richards and by the author that the strong mineral acids cannot be detected by the sense of taste in solutions containing less than 1 gram. mol. in about 1,000 litres. It is now found that solutions of the acid sodium salts of various dibasic organic acids possess an acid taste in solutions containing a considerably smaller number of hydrogen ions than is present in the acid solutions referred to. The acid taste of these salts is hence due, not to the hydrogen ions in the solution, but to the monovalent ions of the formula HAc.

T. H. P.

1327. *Potential Differences with Manganese Dioxide Electrodes.* **O. F. Tower.** (Zeitschr. Phys. Chem. 32. pp. 566–577, March 20, 1900.)—This paper is a further contribution to the method of measuring the concentration of hydrogen ions by means of the P.D. at a manganese dioxide electrode, a method which is specially suited to the investigation of acid salts (*cf.* Zeitschr. Phys. Chem. 18–35, 1895, and W. A. Smith, Zeitschr. Phys. Chem. 21–93, 1896). T. M. L.

1328. *Minimum E.M.F. for Electrolysis.* **A. Gockel.** (Zeitschr. Phys. Chem. 32. pp. 607–624, March 20, 1900.)—In this paper experiments are described, the results of which show that there is no minimum E.M.F. necessary to start electrolysis, but that electrolysis takes place under the smallest E.M.F.'s. Curves are plotted having E.M.F.'s for abscissæ, and current strengths for ordinates. These curves from the start, *i.e.*, from the point at which the current becomes measureable, have an upward slope showing a gradual increase of current with increase of E.M.F. At certain points the inclination increases rapidly and then resumes more or less the straight line form, but the different portions which are approximately straight do not meet at sharp angles but are connected by transition curves. These changes in the slope of the curve take place at the points at which the physical conditions are altered, *e.g.*, the point at which bubbles begin to be evolved.

The current strength for these curves was always observed three minutes after the application of the E.M.F. The electrolytes were solutions of H_2SO_4, KOH, and $ZnBr_2$, and platinum electrodes both in the form of wires and plates were used. J. B. H.

1329. *Electrolytic Conductivity of Sodium Salts of Nitroparaffins.* **O. Šulc.** (Zeitschr. Phys. Chem. 32. pp. 625–629, March 20, 1900.)—The conductivity of solutions of the sodium salts of nitromethane, nitroethane, nitropropane, and nitroisopropane are here determined. The molecular concentrations of the solutions of each salt were 32, 64, 128, 256, 512, and 1,024, and a table is given for each. The following table gives the conductivities for the greatest and least concentration, and their differences, $\Delta = \mu_{1024} - \mu_{32}$.

Sodium salt of	μ_{1024}	μ_{32}	Δ
Nitromethane	108·6	84·4	24·2
Nitroethane	81·9	69	12·9
Nitropropane	80·8	67·8	13·0
Nitroisopropane	93·1 ?	65·0 ?	28·1 ?

J. B. H.

1330. *Production of Ozone.* **H. Bordier** and **Moreau.** (Archives d'Él. Médicale, 8. pp. 57–65, Feb. 1900.)—The authors give the results of experiments made with high-frequency currents and the "Résonateur" or Solenoid of Oudin. The latter is described, but the description requires the accompanying figure. The ozone produced by the non-sparking discharge was estimated quantitatively by the iodine and arsenious acid method. Special tests were made for nitrous products, but always with negative results. It was found that when copper wire was used for the discharge terminal of the apparatus, it became coated with crystals of oxide before the production of ozone attained its maximum, and the authors therefore recommend that copper should be replaced by some less oxidisable metal, or should be plated with gold before use in the Oudin apparatus.

A Rhumkorff coil taking a primary current of 9½ amps., at 58–60 volts, with a Wehnelt interrupter was used in the experiments. Under normal conditions 100 litres of air were aspirated and 65 mgs. ozone were produced per half hour. By increasing the volume of air aspirated it was found possible to greatly increase the yield of ozone. As regards the electrical efficiency of the apparatus, the authors found that while 8 amperes at 48 volts yielded 13 mgs. ozone, 9½ amperes at 60 volts yielded 62 mgs. ozone, the volume of air in each case being 92 litres. They also found that a higher yield was obtained with increase of the sparking length at the terminals of the induction coil. Further experiments proved that the non-sparking discharge was the best condition for a maximum yield of ozone. The authors regard an output of 180 mgs. of ozone per hour as the highest obtainable with the apparatus described. They intend to extend their investigations, and to study the medical value of ozone when inhaled. J. B. C. K.

1331. *Electrolytic Hypochlorites.* **V. Engelhardt.** (Elektrochem. Zeitschr. 6. pp. 253–258, March, 1900, from "Oesterr. Chemiker Zeitung.")—The author, after discussing the numerous advantages attending the use of electrolytically prepared hypochlorites for bleaching purposes, alludes to the fall in the price of calcium hypochlorites, and states that when large quantities have to be dealt with electrolytic bleaching will only pay if salt and electric power can be obtained at very cheap rates. The author confirms the observation first made by Cross and Bevan, that hypochlorite electrolytically prepared, from magnesium or sodium chloride solutions, has a higher bleaching efficiency than the hypochlorite prepared from ordinary bleaching powder, and for solutions of sodium hypochlorite he places the ratio of efficiency at 5:4. His experiments have also proved that dilute solutions of sodium hypochlorite prepared by electrolysis, are more stable than those of calcium hypochlorite, in the light.

The author next discusses the conditions requisite for the production of hypochlorites in the electrolytic cell, and then gives some historical notes relating to the development of electrolytic bleaching processes. The cells of Hermite, Stepanoff, Andreoli, Kellner, Vogelsang, Blackman, Weiss, Schuckert and Co., and of Haas and Oettel are briefly described, and information is given concerning the industrial use of these. The author closes by stating that the problem presented by the electrolytic production of bleaching solutions is now solved, and that the future of the best cells and processes depends only upon local conditions, the growth of the electrolytic alkali and bleach industry, and the price of bleaching powder. J. B. C. K.

1332. *Electrolytic Reduction of Nitrobenzene.* **F. Haber** and **C. Schmidt.** (Zeitschr. Phys. Chem. 32. pp. 271–287, Feb. 20, 1900.)—According to the authors' views of the reactions accompanying the electrolytic reduction of nitrobenzene in alcoholic ammonia solution, phenyl-β-hydroxylamine is formed as an intermediate product; its existence in the reduced solution has, however, only been observed in acid solutions, owing to the fact that in presence of caustic alkali, the phenyl-hydroxylamine suffers decomposition with formation of azoxybenzene and aniline. This decomposition should be avoided by using a solution in which the concentration of the hydroxyl ions is small. The authors find that phenyl-β-hydroxylamine is obtained when the kathode compartment contains an alcoholic ammonia solution of ammonium chloride, the reduction being carried out in the cell devised by Haber [see 1899, Abstract No. 838]; a considerably less current may be employed than is necessary for the reduction in acid solutions. It is also shown that the formation of azobenzene during the reduction of nitrobenzene is not due to the reduction of previously formed azoxybenzene, but that it owes its origin to the action of nitrobenzene on hydrazobenzene by which also azoxybenzene is formed. These results confirm Haber's views of the mechanism of the electrolytic reduction of nitrobenzene in alkaline solutions. T. H. P.

1333. *Electrolytic Reduction of Non-Electrolytes.* **F. Haber.** (Zeitschr. Phys. Chem. 32. pp. 193–270, Feb. 20, 1900.)—The author deduces the formula $E = 0{\cdot}0436\,(\log I - \log C_{NO_2}) - \text{const.}$, for the P.D. between the kathode and kathode-solution in the electrolysis of an aqueous-alcoholic solution of caustic soda containing nitrobenzene as a depolariser, where I represents the current at 20° C., and C_{NO_2} the concentration of the nitrobenzene in gramme molecules per c.c. It was found that the P.D. was only influenced very slightly by the temperature, and a current of cold water was therefore used in place of a more elaborate thermostat. The kathode consisted of a platinum plate, of which only one side was in contact with the solution. The P.D. was measured by a new method, using a capillary electrometer, one terminal of which was connected with the kathode, whilst the other was connected through a vessel containing decinormal solution of KCl to a tube of decinormal KOH, the minute capillary end of the latter being placed in the kathode-solution quite close to the kathode plate.

Three series of experiments were made to verify the laws :—

$$(1)\quad E = 0{\cdot}0436 \log I - \text{const.} \quad (C_{NO_2} = \text{const.}),$$

$$(2)\quad E = 0{\cdot}0436 \log \frac{10}{C_{NO_2}} - \text{const.} \quad (I = \text{const.}),$$

$$(3)\quad \frac{I}{C_{NO_2}} = \text{const.} \quad (E = \text{const.}),$$

With the exception of two experiments in which some unknown cause of disturbance was present, all the measurements showed a linear relationship between concentration and current, as required by law (3), when the current was adjusted to a constant P.D. for varying concentrations of nitrobenzene; the values were most concordant when the value of the P.D. was high. For variations of current from 2·4 to 112 amperes per square metre, the P.D. varies according to law (1) when the constant concentration of the nitrobenzene lies between ⅕ and ⅓ mols. per litre. In six series of experiments with constant current it was found that the experimental factor was always greater than 0·0436, the deviations being greatest when the constant value of the current density was relatively great, since the nitrobenzene then becomes impoverished in the neighbourhood of the kathode. T. M. L.

REFERENCES.

1334. *Theory of Voltaic Cell.* **A. Righi.** (Elect. Rev. 46. pp. 245–247, Feb. 9, 1900.)—This is an appendix to the author's lecture on Volta, delivered at Como, September 18, 1899 (see 1900, Abstract No. 217), and gives a general account of the chemical, contact, and osmotic theories. W. R. C.

1335. *Thermodynamic Relations of Hot Water and Soft Glass.* **C. Barus.** (Amer. Journ. Sci. 9. pp. 161–175, March, 1900. Lecture delivered before the Physical Society of the University of Göttingen.)—This paper appears to be chiefly a summary of the author's work on the above subject. Reference may be therefore made to previous Abstracts, viz., 1899, No. 1045, and 1900, No. 220. F. G. D.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

1336. *Cost of Steam Raising.* **J. Holliday.** (Inst. Elect. Engin., Journ. 29, pp. 38–61. Discussion, pp. 77–117, Jan., 1900.)—This paper deals with the work of a boiler, regarding steam in the pipes as the manufactured article and fuel as the chief raw material. The evaporation of 1,000 gallons of water is taken as the unit work in the boiler. Starting from B. Donkin's figures that the cost of dust coke per unit evaporative work is only about one-third of that of large Welsh coal, the author discusses the disadvantages of the low-priced, poorer fuels—difficulty of burning, more boilers required, more labour needed—which weigh against this economy. Measurements extending over a long period (figures are given for the year 1895) were made on a steam-raising plant consisting of nine approximately equal Lancashire boilers working at 60 lbs. pressure; the demand for steam being fairly constant during the twenty-four hours. All the boilers were hand fired. In three boilers, "breeze," costing 3s. 6d. per ton, was burned, forced draught being used; the mean cost of *fuel alone* per unit was 2s. 8¼d.; each boiler evaporating 2,700 lbs. of water per hour. The other boilers burned a good South Wales coal without forced draught; the mean cost of *fuel alone* per unit being 6s. 9¾d.; evaporation per boiler 3,800 lbs. per hour. Expenses of working, maintenance, insurance, interest, and depreciation come more heavily on the boilers using the poorer fuel than on the others; including these the costs per unit are 7s. 3½d. and 9s. 2d. respectively. Very detailed tables and diagrams are given. H. R. C.

1337. *Cheap Fuels and the Cost of Electrical Energy.* **R. E. Crompton.** (Inst. Elect. Engin., Journ. 29. pp. 62–77. Discussion, pp. 89–117, Jan., 1900.)—After pointing out that, in many instances, as soon as appliances are arranged to use a cheap fuel systematically, so soon is either the price raised or the supply exhausted, the author states that there are large supplies of slack coals available at the collieries in the Midlands and in the North which could in future be delivered within a radius of fifty miles at a cost of about 5s. 4d. per ton, including carriage; beyond that distance it is probably only rarely economical to pay carriage on very cheap fuel. Three classes of cheap fuels are discussed; (1) the anthracitic coals and refuse coke dealt with in the previous paper; (2) the free burning small coals of the Midlands; (3) the small caking coals of the North. The difficulty in the direct burning of the latter two classes is in breaking up the clinker so as to allow a proper supply of air at points in the furnace. Descriptions and diagrams are given of the Babcock and Wilcox revolving grate. In order to obtain increased area of grate and to promote smokeless combustion it is recommended that the revolving grate should project in front from under the boiler into an arched fire-brick combustion chamber. At Chelmsford the ratio of cost of fuel per B.T.U. to total cost is 64 per cent. when using coal at 17s. 5d. per ton; if coal at 5s. 4d. were available it is calculated that the ratio would be only 35 per cent. A table is given of a complete test of a Babcock boiler with revolving grate. In the discussion **J. Perry** pointed out that for stations with a high load factor it is better to use a cheap fuel, while for a low load factor a more expensive coal would be better; for a load factor of about 15 per cent. they would probably be equally economical. **W. Geipel** referred to the advantages of a rib beneath the furnaces of a Lancashire boiler in promoting circulation and hence getting up steam more quickly. **F. J. Appleby** considered the powdered fuel method to be the best way of burning the small bituminous coals of the North. H. R. C.

1338. *Efficiency of Steam Boilers and Surface Condensers.* **T. E. Stanton.** (Mech. Eng. 5. pp. 445–448, March 31, 1900. Paper read before the Owens College Engineering Society.)—This communication refers to experiments made by the author which confirm Osborne Reynolds's theory that the rate of transmission of heat between a metal surface and a fluid in contact with it, for a given difference of temperature between the surface and the fluid, is proportional to the quantity of the fluid carried up to the surface in unit of time. The author's experiments on water show that the rise in temperature of water flowing through a tube, the surface of which is kept at a constant temperature, is practically the same at all velocities above the critical velocity at which eddying motion is established in the tube. The paper is illustrated by diagrams showing the temperature in a condenser, having a tube surface of 176 square feet when the supply of cooling water is 15·5 pounds and 25 pounds respectively per pound of steam. In another diagram the relation between length of tubes and condenser pressure is shown for the three cases of tubes ⅜ inch, ⅝ inch, and ⅞ inch in diameter. The curves clearly show that the smaller the diameter of the tube the less the effective length need be to produce a given pressure. As an example with a given supply of steam and cooling water, the effective lengths of tube for a pressure of 1·68 pounds per square inch would be proportional to 26·8, 18·2, and 10·0 for tubes of ⅞, ⅝, ⅜ diameter respectively.

A diagram is given, indicating the arrangement of tubes suggested by the results of these experiments for a condenser of high efficiency. E. C. S.

1339. *Rules for Conducting Steam Boiler Trials.* (Engineering, 69. pp. 271–272, Feb. 23, 1900. Report presented at the Dec. (N.Y.) Meeting of the American Society of Mechanical Engineers.)—The following is a short epitome of the rules laid down for conducting boiler trials:—

(1) Determine accurately object for which trial is instituted and scope of same. (2) Examine boiler carefully both inside and outside, recording all the principal dimensions, giving sketches when possible, state heating surface (both "water heating" and "steam heating") and grate surface.

(3) Note general conditions of boiler and setting and their relation to the object of the trial. Ensure cleanliness and absence of leaks either of air or steam. (4) Determine character of coal. (5) Calibrate all measuring tanks, scales, gauges, thermometers, &c.

(6) See that the boiler and setting are thoroughly heated before test commences.

(7) Boiler and connections must be free from leaks, and all connections other than those actually in use should be blank-flanged and should remain as far as possible in view during trial.

(8) Duration of trial should be as long as can be conveniently arranged for; if possible, not less than twenty-four hours if test is conducted under ordinary working conditions with change of stokers, &c.

(9) Conditions at the start and finish of the trial should be identical as far as possible.

(10) "Standard" method of starting trial consists in raising steam to working pressure, removing fire and ashes, making new fire of weighed quantity of wood and coal, noting the time and the water level. At the end of the test remove whole fire, clean grates and ashpit, noting time and water level, which should be as nearly as possible what it was at commencement of trial.

(11) "Alternate" method of starting trial. Burn fires low and clean. Note fuel left on grate as accurately as possible, also steam pressure and water gauge. Take time of starting and weigh fresh coal as it goes on. Towards end of trial bring fires as nearly as possible to the same condition as at starting, and make same observations as to quantity of coal on grate, water level and steam pressure, and make the necessary allowances.

(12) Endeavour to obtain uniformity, as far as possible, of conditions throughout the duration of the trial and also for any trials which have to be compared with one another. (13) Take note of every event occurring during the trial and time of its occurrence. Stoking and feeding must be by equal quantities at equal intervals. (14) Percentage of moisture in the steam should be determined by means of a calorimeter, and if necessary a separator should also be added. Superheating should be determined by a thermometer placed in a mercury well in the steam-pipe.

(15) Samples of coal should be collected throughout the trial and then gradually reduced until a fair average sample of about 5 lbs. is procured, which should then be placed in an air-tight glass for subsequent analysis. (16) Representative samples of the ashes should also be procured for the same object. (17) The calorific value of the coal should also be determined by a competent chemist. (18) The fuel gases should also be sampled at stated intervals and the analysis made by an expert chemist, or the Orsat and Hempel apparatus may be used for an approximate determination. (19) Observations of the quantity of smoke should be made. (20) Efficiency may be calculated in either of the following methods :—

$$(a)\text{ Of boiler} = \frac{\text{Heat absorbed per lb. of combustible}}{\text{Calorific value of 1 lb. of combustible}}$$

$$(b)\text{ Of boiler and grate} = \frac{\text{Heat absorbed per lb. of coal}}{\text{Calorific value of 1 lb. of coal}}$$

(21) Heat balance should, where possible, be added to all results of trials.

L. S. R.

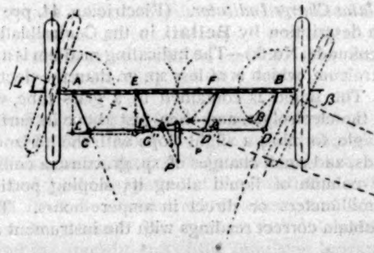
1340. *Mean Pressure Indicator.* **W. Ripper.** (Inst. Mech. Engin., Proc. 4. pp. 569–584. Discussion, pp. 584–612, 1899. Mech. Eng. 5. pp. 122–124, Jan. 27, 1900.)—A description of the author's indicator for measuring the mean effective pressure on the pistons of high-speed engines. The readings are taken on two gauges, one of which is always in connection with the driving or high pressure side of the piston, and the other is always in connection with the back pressure side. The difference in the readings of the gauges is the mean effective pressure. Oscillations of the gauge fingers are controlled by throttling the steam by means of two cocks on the pipe leading to each gauge. The author describes the different forms of the instrument, and then considers the mean pressure given by his indicator in comparison with those given by the ordinary type of indicator, as the mean pressures given by an ordinary indicator are on a distance base, while with this instrument they are on a time base, and shows how to obtain a factor for reducing one to the other. The author next deals with the care of pressure gauges, and describes the experiments carried out to ensure the gauge syphon remaining full of water and free from agitation, which he effects by means of two cocks for throttling the steam.

In the discussion **H. Lea** described a continuous indicator brought out by himself. **S. H. Terry** described a dial steam power meter designed to register (1) the mean effective pressures on piston, (2) the speed of the piston, and (3) the I.H.P. **E. Savage** wrote of Janet's experiments at Creusot on similar lines to the author's.

Numerous illustrations accompany the paper. L. S. R.

AUTOMOBILISM.

1341. *Steering Gear.* (Locomotion Automobile, 7. pp. 279–280, May 3, 1900.)—A description of Griffisch's arrangement of levers whereby more correct positions of the steering wheels of motor vehicles are obtained when turning.



Five diagrams are given explaining the method employed. The figure, reproduced, shows the arrangement very clearly; P is the centre about which the mechanism is operated by the driver; the lines A C and B D intersect at the centre of the rear axle of the vehicle. A. G. N.

1342. *Uses of Acetylene.* **Janet.** (Ecl. Électr. 22. pp. 197–200, Feb. 3, 1900. Paper read before the Société d'Encouragement pour l'Industrie Nationale, Jan. 26, 1900.)—For lighting purposes acetylene gas is (1) produced from calcium carbide in a generator where used; and (2) the gas is stored under pressure or in solution in a suitable portable receiver. Compressed acetylene may be used to light carriages and for railway signals (instead of oil gas) at a cost of 0·8 centime per *carcel-heure.* Two small types of generators are described. W. R.

REFERENCES.

1343. *Combustion and Forced Draught.* **R. B. Hodgson.** (Mech. Eng. 4. pp. 968–970, Dec. 30, 1899, and 5. pp. 22–24, Jan. 6, 1900. Paper read before the Birmingham Association of Mechanical Engineers, Nov. 4, 1899.)—The author describes the combustion, constituents, and calorific values of coal of several qualities; the amount of air required for combustion, the different methods of forcing and inducing draught, and their relative advantages and disadvantages. J. T. R.

1344. *Balancing Marine Engines.* **J. Macfarlane Gray.** (Engineering, 69. p. 487, April 13, 1900.)—The author gives some geometrical constructions, and refers to papers by himself in the Transactions of the Institution of Naval Architects. A. S.

GENERAL ELECTRICAL ENGINEERING.

1345. *Characteristic Curves of Accumulators.* **M. Kohn.** (Elektrotechn. Zeitschr. 21. pp. 78–80, Jan. 25, 1900.)—The method of tracing the characteristic curve of a battery is described, the ordinates representing terminal voltage, and the abscissæ the current on charge and discharge. By plotting on the same diagram the characteristic curve of a dynamo, the proportion of an external load which will be taken by each when connected in parallel can be determined. The effects of internal resistance of the cells and of variations of dynamo speed are traced and the method detailed of designing the capacity and resistance of a buffer battery required to effect any desired damping of the variations due to external load, as on a tramway circuit. L. B.

1346. *Accumulator Charge Indicator.* (Electrician, 44. pp. 781–782, March 23, 1900. From a description by **Bellati** in the Centralblatt für Accumulatoren- ŭ. Elementenkunde, No. 3.)—The indicating medium is a column of some liquid, such as petroleum, which is of less sp. gr. than the electrolyte, and does not mix with it. The liquid is contained in a glass tube, which passes up vertically through the electrolyte, and then just above its surface bends over nearly at a right angle, forming a slight slope with the horizontal. The tube is open at both ends, and small changes of sp. gr. cause a considerable travel of the top of the column of liquid along its sloping portion which may be graduated in millimeters or direct in ampere-hours. The precautions to be observed to obtain correct readings with the instrument are given. E. J. W.

1347. *Active Materials for Lead Accumulators.* (Electrician, 44. pp. 785–786, March 23, 1900. From an article by **A. Heinemann** in the Centralblatt für Accumulatoren- ŭ. Elementenkunde, No. 5.)—The use of organic substances for mixing with the lead oxides for pasting purposes is discussed. Materials which furnish products of a resinous nature upon oxidisation are preferred, and the author favours a strongly compressed active material of small porosity, agglomerated with oils of cypress, birch, or pine. E. J. W.

1348. *Accumulators.* **M. U. Schoop.** (Zeitschr. Elektrotechn., Wien, 18. pp. 101–106, Feb. 25, 1900.)—This is a paper dealing with a series of tests of positive and negative plates of accumulators for the purpose of ascertaining their relative capacities at different rates of discharge. The method employed was to take readings at intervals between the plates and a neutral electrode of mercury—a known method—during discharge. The results are summed up as follows: (1) Negative plates are much more sensitive to excessive rates of discharge than positive (peroxide) plates of the same absolute capacity. Put in another way, this means that a given battery, which will, if discharged at a slow rate, give so many ampere hours, will, of course, when discharged at a a high rate, give less; *but* that the difference is due to loss of capacity at the high rate on the part of the negatives—not on the part of the positives. (2) Compared with pasted negatives, Planté *negatives* lose their capacity in from 10–25 discharges. (3) In Planté *positives* the active material is used more effectively than in pasted positives, *but* the pasted positives "pick up" better on a rest.

(4) In Planté batteries where negative and positive capacity is about equal, the resistance is distributed in practically the same way as in Faure batteries. (5) Generally, and more especially when the batteries are exposed to extreme loads (buffer batteries and motor-car batteries), the capacity of the negatives should be greater than that of the positives. R. N. L.

1349. *Accumulators in the Paris Club Trials.* **A. Bainville.** (Électricien, 19. pp. 51–55, Jan. 27, 70–73, Feb. 3, 81–85, Feb. 10, 134–137, March 3, 149–153, March 10, 167–169, March 17, 1900.)—None of the cells stood the 153 complete charges and discharges. All were lead-lead cells, and some of the best are entirely new designs. The "Metaux" and "Pollak" are minutely detailed and illustrated. In pages 70–73 are described the "Tudor" and "Pescetto" cells; the grids of the latter are particularly intricate. In pages 81–85 the author describes the "Blot Fulmen," which has special provisions for free expansion of the positive paste by supports made of wavy strips unconfined laterally. The "Fulmen" has grids filled with cakes of paste. "Phœnix" plates consist of small pasted cylinders 2 mm. in diameter protected individually by a continuous pile of ebonite washers 1 mm. thick. The "Pope" positive plate consists of seven lead spirals pasted and protected by a spiral of ebonite which covers half its surface. The negative is a pasted grid. [See also Abstracts Nos. 952 and 953 (1900).] M. O'G.

1350. *150-Ton Electric Crane at Bremerhaven, Germany.* (Eng. News, 43. pp. 99–101, Feb. 8, 1900; from the "Zeitschrift des Vereines deutscher Ingenieure.)—The superstructure of the crane consists of a rigid supporting tower and a revolving mast supported at the foundation and at the top of the tower; the mast itself is a framework structure, and carries at the top a double-armed cantilever truss. The carriage with the hoisting gear runs on the cantilever, and the opposite end of the cantilever bears a counterweight so proportioned that the negative bending moment arising from it when the carriage is at its inner position equals the positive moment due to the maximum load at the extreme length of the arm. The total weight of the mast, counterweight, and load produces a vertical pressure which is transmitted from the mast through a hinge to a revolving platform resting on rollers. The total height of the crane is 118 feet from the top of the foundations, and the total reach is 72 feet, giving a useful reach of 44¼ feet from the front of the masonry wharf to the middle of the hook.

The turning mechanism is actuated by a direct-current motor of 26 H.P. at 550 revs. per min.; a worm gear and spur gears transmit the motion to the mast in four reductions, the total reduction being 1 : 4,000. The cantilever therefore requires 7·2 minutes to make a complete revolution. The circumferential motion of the hook at its extreme position is therefore 81¼ feet per min., and is accomplished under maximum load; with a smaller load a greater speed can be obtained.

The steel lifting cable is 2·36 inch diameter, and has a breaking strength of 150 tons over a pulley of 47¼ inches diameter. The tackle-block has seven sheaves corresponding to eight plies of the cable. It did not seem practicable to wind the unusually long cable on a drum borne by the carriage; but two barrels or pulleys are provided which in their action correspond to a single pulley encircled an equal number of times. The number of turns is six, and the calculated tension in the cable as it leaves the last pulley is 16 lbs. The slack end of the cable runs upon supporting rollers to the middle of the mast, and to a pair of blocks, through which it makes twelve turns. The lower block is weighted and runs between guides, the tension produced in the cable being 1,100 lbs.

Two series-wound motors, each delivering 17½ H.P. at 450 revs. per min., operate the lifting tackle. They are connected by flexible couplings to a common spindle, from which the rotation is transmitted by two sets of spur gears to a third spindle lying between the two cable pulleys; on this latter spindle are fixed two pinions engaging with four spur wheels bolted to the pulleys. Two sets of electromagnetic and mechanical brakes are provided, all working automatically. The mechanical brakes act as a reserve in case of a failure of the magnetic brakes. They are fully described in the paper.

The movement of the carriage is effected by a motor which develops 26 H.P. at 550 revs. per min. The motion is transmitted by a worm gear to two pairs of spur gears. The motors operate at 110 volts, and are similar to street car motors. The weight of material used in the supporting tower and cantilever, turning machinery, cable and blocks, carriage and pulleys, is 412 tons. The weight of an American 150-ton crane referred to for comparison is 775 tons. A. S.

REFERENCES.

1351. *E. C. C. Electrical Lift Gear.* (Electrician, 44. pp. 289–290, Dec. 22, 1899.)

1352. *Meters.* **H. Armagnat.** (Écl. Électr. 21. pp. 161–172, Nov. 4; 295–301, Nov. 25; 412–419, Dec. 16, 1899.)—Illustrated description of meters of Sherman-White, Peloux, Boult, Routin-Brown, Mohrle, Marks, Locke, Thomson-Holden, and O'Keenan (pp. 161–172).—Meters of Bastian, Edison, Thomson, Allo, Soames, Crawley, and Raphael (pp. 295–301).—Recent improvements in meters including those of Long-Schattner, Batault, Laarman-Brockelt, Chamberlain and Hookham, Thomson, Davis, Staunton, Jones, and Evershed and Vignoles (pp. 412–419). (See also 1899, Abstracts Nos. 168, 1421.)

1353. *O'Keenan Electricity Meter.* **C. E. O'Keenan.** (Soc. Int. Élect., Bull. 16. pp. 391–409, 1899.)—Descriptive paper, including results. (See 1900, Abstract No. 580.)

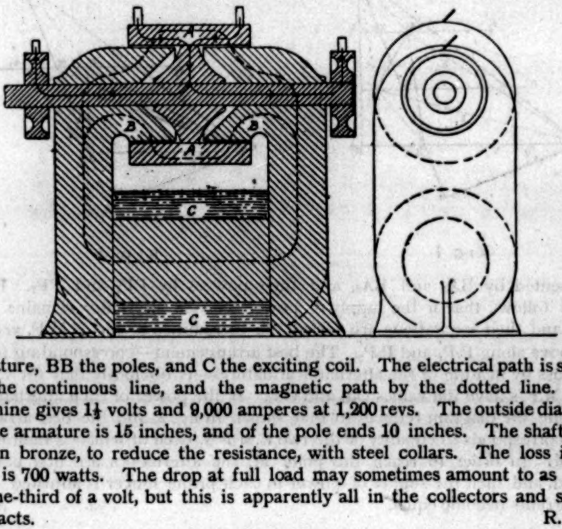
1354. *Electrical Engineering.* **S. P. Thompson.** (Inst. Elect. Engin., Journ. 29. pp. 14–35, Jan., 1900.)—This is an inaugural address in which the author gives an account of the present position and tendencies of electrical engineering. Particular attention is called to the marked effect which the *amortisseur* of M. Leblanc has upon the parallel running of alternators, to the application of electric power to heavy railways, and to progress in contact systems for tramways. W. R. C.

1355. *Central Station Buildings.* **C. S. Peach.** (Elect. Engin. 25. pp. 309–311, March 2, and 336–340, March 9, 1900. Lecture delivered at Carpenter's Hall, March 1, 1900.)—A lecture on the subject of the architectural points necessitated by engineering considerations.

1356. *Sag of Overhead Lines.* **M. Jüllig.** (Elektrotechn. Zeitschr. 20. pp. 886–889. Dec. 21, 1899.)—From the catenary equation $y = \frac{h}{2}\left(e^{\frac{x}{h}} + e^{-\frac{x}{h}}\right) = h \cosh \frac{x}{h}$ the sag and length of wire required in an overhead span between posts of unequal height to give a minimum stress in the wire are calculated. A table of hyperbolic functions of angles up to 4° is given, and several actual examples worked out in full. L. B.

GENERATORS, MOTORS, AND TRANSFORMERS.

1357. *Commutatorless Dynamo Design.* **H. E. Heath.** (Elect. World and Engineer, 35. pp. 210–211, Feb. 10, 1900.)—For electrochemical and electrometallurgical purposes the current produced by a commutatorless dynamo is superior to that from any other form of machine. With the ordinary form of low potential dynamo the current is to an appreciable extent pulsating, owing to the few commutator segments. Three forms of commutatorless or unipolar dynamo are given, one of which is here reproduced. AA is the armature, BB the poles, and C the exciting coil. The electrical path is shown by the continuous line, and the magnetic path by the dotted line. This machine gives 1½ volts and 9,000 amperes at 1,200 revs. The outside diameter of the armature is 15 inches, and of the pole ends 10 inches. The shaft is of Tobin bronze, to reduce the resistance, with steel collars. The loss in the field is 700 watts. The drop at full load may sometimes amount to as much as one-third of a volt, but this is apparently all in the collectors and sliding contacts. R. B. R.



1358. *Composite-Wound Polyphase Alternators.* (Amer. Electn. 12. p. 51, Jan., 1900.)—This is a description of a method employed by the Westinghouse Electric Company for compounding alternators for constant potential under varying loads. The arrangement consists of a series transformer mounted on the spokes of the armature of the alternator and rotating with it. By means of this series transformer the voltage delivered to a rectifying commutator and the fields is much less than that generated by the machine. In polyphase machines this transformer, instead of having one primary, has two or three, according to whether the machine generates two or three phases. W. G. R.

1359. *Parallel Running of Alternators.* **G. Chevrier.** (Écl. Électr. 22. pp. 401–405, March 17, 1900.)—Making use of the graphical construction suggested by C. F. Guilbert [see 1900, Abstract No. 342], the author applies it to explain what proceedings are necessary to make the power factor for the branched circuit consisting of the alternator armatures as high as possible. In fig. 1, OC is the external current vector, OB the P.D. vector. If there is only a single alternator, then, neglecting the resistance drop, the inductance drop in its armature will be represented by BA, which is in line with CB, the inductive drop in the external circuit. BA is thus proportional to the current, and to a suitable scale represents the current vector rotated through 90° in advance of its actual position. OA gives the E.M.F. Further, the power developed by the alternator is proportional to the area of the triangle BOA, *i.e.*, since OB is constant, to PA. If there are two alternators, whose E.M.F.'s are E_1 and E_2, then (fig. 1) their currents will, to a suitable scale, be represented by BA_1 and BA_2, and their powers by PP_1 and PP_2. From this it follows that if the supply of power to each alternator remains constant, and their excitations are varied, the extremities of the E.M.F. vectors will move along P_1P_1' and P_2P_2'. The best arrangement—corresponding to the least loss by heating of the alternator armatures—is obviously that for which the E.M.F.'s have the values Oa_1 and Oa_2. If the power of each alternator is the same, the diagram reduces to that shown in fig. 2, and the best arrangement corresponds to equality of the two E.M.F.'s, each of which is then equal to OM. In order to reach the point M, the alternators are first equally excited, and then the supply of power to each prime mover is adjusted until the currents become equal. A. H.

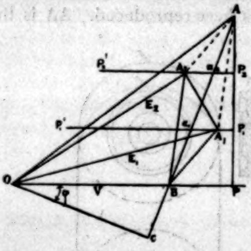


FIG. 1

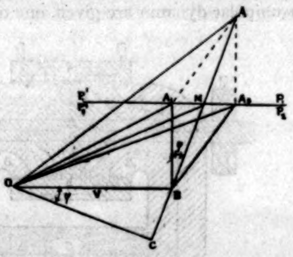


FIG 2.

1360. *Parallel Running and Hunting of Alternators.* **H. Görges.** (Elektrotechn. Zeitschr. 21. pp. 188–193, March 8, 1900.)—The paper is divided into two parts. Part I. deals with the graphical representation of the E.M.F.'s currents and powers in a vector diagram. Part II. is devoted to the problem of hunting. The differential equation of the oscillations which are superposed on a uniform motion of rotation is first deduced, damping being taken into account. The author then considers (1) the natural oscillations of the alternator when displaced from its normal phase relation to the 'bus bar P.D.; (2) the forced vibrations due to fluctuations in the torque of the prime mover. Observations on actual alternators are in agreement with the results of theory. The formula deduced by the author for the natural period of vibration agrees with those previously obtained by Boucherot, Blondel, and Kapp [see 1900, Abstracts Nos. 840 and 841]. In order to avoid troublesome hunting, the author recommends the use of prime movers whose torque passes through a number of periods during each revolution. A. H.

1361. *Alternating-Current Motors.* **W. A. Layman.** (Mech. Eng. 5. pp. 80–82, Jan. 20, 128–130, Jan. 27, and 170–172, Feb. 3, 1900. Paper read before the Engineers' Club of St. Louis, and reprinted in the "Journal of the Association of Engineering Societies.")—After giving a description of induction motors in general the author proceeds to describe in detail one manufactured by the Wagner Electric Manufacturing Company of St. Louis, for which a large starting torque is claimed. In these machines the armature cores are wound with an ordinary direct-current progressive winding, connected up to a commutator in exactly the same fashion as in the direct-current motor winding. The commutator of this armature is so designed that it may be completely short-circuited by introducing a short-circuiting circle of copper segments. When so short-circuited this winding differs from the squirrel cage only in that, instead of the currents being left to select paths for themselves they are restricted to flowing in paths afforded by the individual coils of the armature winding. The commutator is of the radial type. The short-circuiting band is made up of small copper links, which, being mounted upon a short-circuiting ring, are thrown into an angular opening in the commutator, and by making close contact with each segment it short-circuits the whole armature. The starting arrangement is shown in fig. 1, which shows a starting resistance placed between brushes rubbing on the commutator. Figs. 2, 3, 4, show respectively the relations between starting torque and current, efficiency and load, and power factor and load. W. G. R.

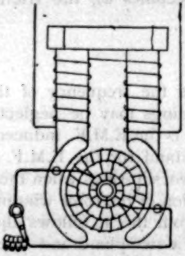


Fig. 1.

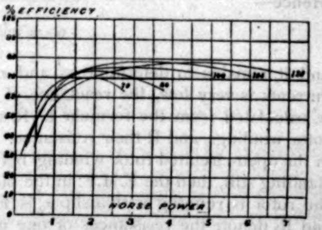


Fig. 3.

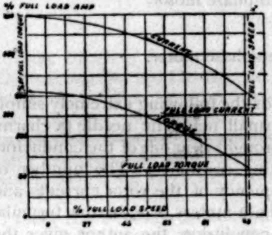


Fig. 2.

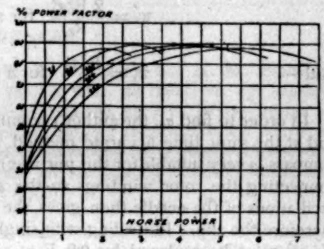


Fig. 4.

1362. *Friction Losses in Induction Motors.* **F. Blanc.** (Elektrotechn. Zeitschr. 21. pp. 131–133, Feb. 15, 1900.)—Referring to Braun's article on this subject [see 1900, Abstract No. 349], the author states that the only unsatisfactory feature about method (4) is the fact that the experimental determination of N/N_0 is very laborious if accuracy is required. He then describes the following method of finding the friction loss (this method being, however, only applicable to motors provided with slip-rings). Let w_c = copper loss, in watts, in rotor windings when the motor is loaded, w'_c = ditto when running light; w = power, in watts, employed in turning rotor; σ_0 and σ = slip of rotor, expressed as fraction of synchronous speed, when the motor is running light and loaded respectively. Then we have—

$$\frac{w_c}{w} = \frac{\sigma}{1-\sigma}$$

Now when the motor is running light, w becomes w_f, the friction loss. Hence—

$$w_f = w'_c \frac{1-\sigma_0}{\sigma_0},$$

and it remains to determine w'_c and σ_0. Since the frequency of the rotor currents is very low, the reactance of its windings may be neglected, and w'_c calculated from the formula E^2/R, where E is the E.M.F. induced in the rotor windings, and R their resistance. If E_0 stand for the E.M.F. induced in the open-circuited rotor winding between two slip-rings when the rotor is standing still, then the E.M.F. in the same portion of the rotor winding when the rotor is running with a slip σ_0 is $E_0\sigma_0$. From this it follows that if R_2 and R_3 denote the resistances of one phase of a two-phase and three-phase motor respectively—

$$w'_c = \frac{2\,E_0^2\sigma_0^2}{R_2} \quad \text{for a two-phase motor,}$$

and—

$$w'_c = \frac{E_0^2\sigma_0}{R_3} \quad \text{for a three-phase motor.}$$

In order to find σ_0, the author recommends the following extremely simple and at the same time accurate method. A small magnetic needle (a charm-compass is very suitable for this purpose) is brought near one of the conductors connecting the rotor windings to the starting resistance. The number of oscillations of the needle then gives the frequency of the rotor currents and therefore the slip. In dealing with single-phase motors, $E_0\sigma_0$ in the formulæ for w'_c must be replaced by $0{\cdot}9\,E_0\sigma_0$. In conclusion, the author gives the following formula for the friction loss, and states that it has been found applicable to motors from $\frac{1}{10}$ to 300 H.P.:

$$w_f = C\sqrt{\text{H.P.} \times D},$$

where D is the rotor diameter in cms., and C is a constant depending on the construction of the bearings and ranging from 20 to 30. A. H.

1363. *Transformers at Niagara.* (Elect. World and Engineer, 35. pp. 227–228, Feb. 10, 1900.)—A description of a set of 1875 kw. Westinghouse oil-insulated transformers, which are the largest hitherto made. They are used for transforming from 2,200 volts two-phase to 11,000 volts three-phase by Scott's method. Each measures 9 feet high by 7 feet in diameter, and weighs 30,000 lbs., including oil. The efficiency at full load is 98·5 per cent., at quarter-load 97·6, and at one-tenth load 94·6; the iron loss being 0·54 per cent., and the full load copper loss 0·96 per cent. The secondary drop at full non-inductive load is only 1 per cent. The 13 per cent. reduction in voltage, required for the secondary of one transformer of a Scott-connected pair, is obtained by cutting in more turns in the primary; and in a similar way the 5 per cent. adjustment in secondary voltage, necessary for regulating with different loads, is conveniently carried out. W. H. E.

1364. *Magnetic Leakage of Induction Motors.* **M. Breslauer.** (Zeitschr. Elektrotechn., Wien, 18. pp. 99–100, Feb. 18, 1900.)—The following formulæ give the minimum power factor $\cos\phi$, the normal power current C_w, the magnetising current C_m, and the no-load current in terms of the leakage factor u for induction motors—

$$\cos\phi = \sqrt{\frac{2-u}{2+7u}},$$

$$C_o = \frac{2\,C_m}{1+u},$$

$$C_w = \frac{C_m}{1+u}\sqrt{\frac{2-u}{2u}},$$

To increase the power factor the leakage must be reduced as far as possible. Hence the modern tendency to large diameters at the expense of length in rotors. The above formulæ are compared with the results of tests of 2 and 20 H.P. induction motors which gave leakage factors of 0·11 and 0·08 and power factors of 0·84 and 0·82 respectively. L. B.

REFERENCES.

1365. *Design of Rotary Converters.* **H. F. Parshall** and **H. M. Hobart.** (Engineering, 68. pp. 721–723, Dec. 8, 783–784, Dec. 22, 1899; 69. pp. 197–198, Feb. 9, 241–244, Feb. 23, 499–501, April 20, and 535–536, April 27, 1900.)—Design of rotary converters, including that of a six-phase, 400-kw., 25-cycle, 600-volt converter (pp. 783–784); tabulated calculations and specifications for a 900-kw. three-phase rotary converter (pp. 197–198); and notes on the starting of rotary converters (pp. 241–244). [See also Abstract No. 361 (1900).]

1366. *Hutin-Leblanc Method of Compounding Induction Generators.* **Wessely.** (Zeitschr. Elektrotechn., Wien, 18. pp. 133–135. Discussion, pp. 135–136, March 11, 1900.)—A description of the devices noticed in Abstracts Nos. 620 and 908 (1899). A. H.

1367. *Dynamo Design.* **E. K. Scott.** (Elect. Rev. 46. pp. 342–345, March 2, and 429–430, March 16, 1900.)—Articles dealing with some mechanical aspects of dynamo design.

1368. *Dynamo Testing and Tending.* **N. C. Woodfin.** (Mech. Eng. 5. pp. 263–265, Feb. 24, 309–311, March 3, 351–353, March 10, and 388–390, March 17, 1900. Read before the Glasgow and West of Scotland Scientific Society, Jan. 27, 1900.)—A brief outline of the arrangements and methods employed in testing new dynamos. A. H. A.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRIC DISTRIBUTION.

1369. *Power Transmission with Constant Current.* **H. Cuénod** and **R. Thury.** (Soc. Int. Élect., Bull. 17. pp. 9–93, Jan., 1900.)—This paper describes the Thury system, and includes an account of installations where it is employed. The aggregate capacity of the plant installed since 1893 amounts to 17,500 H.P., including a 5,000-H.P., 22,000-volt plant, now under construction, to supply Lausanne from St. Maurice, 56 km. distant, where water power is to be taken from the Rhone.

The power is generated in each case by a number of direct-current dynamos connected in series according to the voltage required, and giving a constant current. The motors to be worked in the circuit are all designed to take the same current, the voltage of each depending on its output. The maximum voltage of each dynamo varies in different cases from 1,000 to 3,500, and the greatest current hitherto used is 250 amperes. The dynamos are mostly drum-wound, six-pole, and are in some cases excited independently. No trouble is experienced from sparking on the commutator, the number of segments being such that the voltage between adjacent segments does not exceed 15, in machines for the higher pressures.

When the engine or turbine is to run at a fixed speed, and the dynamos are self-excited, the current is automatically kept constant by a regulator which, between full and ¾ voltage, shunts the field, and for lower voltages moves the brushes. If separate excitation is employed, the exciter is driven by its own turbine, whose speed is automatically adjusted by the main current. Usually, however, the engine is arranged to run at a variable speed, giving a constant torque: the opposing torque varies nearly as the square of the current, and hence the current remains nearly constant. With turbines the applied torque varies with the speed, and therefore the self-regulation is not so exact. But, in either case, occasional hand regulation is sufficient; or the control may be automatic, *e.g.*, by means of a series motor carrying the main current, whose armature, resisted by a yielding spring, actuates the valves of the turbines.

Motors have their speed automatically controlled by one or more of three methods:—

(1) Regulating the field; either by a resistance in shunt or by changing the field connections so as to put some of the windings in opposition to the others. (The latter principle can be used for reversing if required.) This is the method most used, but is not suitable for motors of over 100 H.P., owing to sparking at the brushes.

(2) Changing the position of the brushes.

(3) Using secondary cells in shunt with the brushes. This method is employed only for motors under 10 or 15 H.P., preferably compound-wound. When the load is light the cells are changed, the torque being thus increased and the speed kept down. The energy stored can be used at times of heavy load.

In case of excessive speed the motor is short-circuited by a centrifugal device. And if the terminal voltage becomes too great (*e.g.*, by a break in the circuit) an electromagnetic by-pass comes into action. As a protection against a very sudden rise in voltage, such as sometimes arises from atmospheric "circulatory discharges," a lightning-arrester is connected across the poles, in addition to the two between poles and earth.

The efficiency of a 300 H.P. motor was found to be 93½ per cent.

Distribution for lighting and for small motors is carried out by means of motor-generators giving constant pressure. In one case the reserve plant includes dynamos which can give either constant current (with separate excitation) or constant pressure (with shunt excitation), and can therefore be used either in the primary or the secondary, as desired. W. H. E.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

1370. *Utilisation of Schaffhausen Water Power.* **A. Amsler.** (Inst. Elect. Engin., Journ. 29. pp. 175–184. Discussion, pp. 184–191, March, 1900.) The original installation in which the power from the turbines was transmitted by wire ropes for a distance of 600 metres along the bank of the river is now being replaced by electric transmission. Owing to the wearing and loosening of the pulleys the speed of the turbines had to be reduced from 40 to 30 revolutions per minute; the average life of the ropes has latterly become less than a year, the expense of renewal being 35 per cent. of the total income.

Francis turbines are to be used driving alternators at a pressure of 2,000 volts; the power is to be delivered to consumers at a price of 125 francs a year per B.H.P. measured at the motor.

In the discussion **F. Prášil** gave an investigation of the transformer turbine in which part of the water supply is used to drive a ring of vanes intermediate between the fixed vanes and the motor wheel; an artificially increased head is thus given to the water passing through the motor wheel and the speed of the latter increased. His conclusion is that transformer turbines would only be suitable for low, variable heads and direct coupling. H. R. C.

1371. *Metropolitan Electric Supply Company's Works, Willesden.* (Electrician, 44. pp. 691–697, March 9, and 733–738, March 16, 1900.)—The load on this supply company's stations in London has grown to such an extent that it has been found necessary to increase the generating plant and also to provide for further large extensions in the future. For this purpose large works have been erected at Willesden, where a very suitable site was procured, about nine acres in extent, adjacent to the London and North-Western main railway line, a branch line of the Midland Railway, and the Grand Junction Canal. There are, consequently, ample facilities for the supply of coal either by rail or by water. The coal can be conveyed either from the canal or the railway siding by means of a conveyer, constructed by the Temperley Transporter Company, which carries coal directly into bunkers on the roof of the boiler house. The bunkers can store about 1,000 tons of coal. The coal is lifted in skips, each containing 15 cwt., to the transporter beam, a height of 55 feet. It is then carried by the traveller into the bunkers, the maximum travel being 274 feet. The full skip *en route* to the boiler house is stopped and lowered to the platform of a weighing machine; after being weighed it is again taken up and carried to the bunkers, where each skip is automatically tipped. Electrical power is used for the conveyer.

The boiler house contains sixteen Babcock-Wilcox boilers, working at 160 lbs., and fitted with Babcock-Wilcox steam superheaters. Six of the boilers are hand fired, eight are fitted with Vicars automatic stokers, and the other two with Babcock-Wilcox chain-grate stokers. The water used is taken from the canal.

The engine-room plant consists of three large Westinghouse sets; the generators are two-phase, yield 1,500 kw. each, the pressure of each phase being 500 volts, and the frequency 60 per second, with a specified efficiency at full load of 95 per cent. The armatures were tested at 5,000 volts. The exciters are six-pole machines and yield 450 amperes at 100 volts. Each alternator and its exciter is directly coupled to a Westinghouse vertical compound enclosed marine type engine running at 116 r.p.m. There is a surface condenser placed behind each engine. These have been supplied by the Wheeler Condenser and Engineering Co., are of their Admiralty pattern, and each has a cooling service of 4,000 square feet. In connection with each is a Blake-Knowles combined air and circulating pump, the two pumps being connected to the same rocking lever. Between the engine and pump is an automatic valve operating a by-pass to an open-air exhaust if the vacuum in the condenser fails. The circulating water is cooled by three Barnard cooling towers, capable of cooling 8,000 gallons of water per hour from 130° F. to 80° F. Their dimensions are 12 ft. 3 in. × 12 ft. × 37 ft. each. The fans are driven by small Bumsted-Chandler engines. A switchboard in the engine-room forms the connecting link between the generators and the high-pressure switch-room.

The overhead travelling crane is by Higginbottom and Mannock; it has a span of 50 feet, and is rated at 35 tons, having been tested up to 50 tons. It is driven by one electric motor for all three motions.

The step-up transformers are installed in a separate room together with the high-pressure switching gear. The transformers, fourteen in number, of 250 kw. capacity each, were made by the British Electric Transformer Manufacturing Company, and are of the Berry type. The transformers for each of the two phases are independent of one another; they are not in cases, and, being thoroughly ventilated, very cool running is attained. The primary coils take 497 amperes at 523 volts, and the secondary coils yield 23 amperes at 11,000 volts. One pole of the high-pressure windings is earthed; no earth shields or earthing devices are used. The high-pressure switching gear has been designed throughout by G. W. Partridge; a fully illustrated description of it is given. On the switchboard the two phases are separated, one being brought to each side. All the outer conductors of the concentric mains are coupled together and earthed. Two fuses in parallel are used in each case, one only being used for light loads; the second fuse is put in circuit as the load gets heavier. The fuses are of tinned copper wires in stoneware tubes 4 ft. 6 in. long. The mains are not switched directly on to the transformers; the circuit is first closed through the primary of a charging transformer placed in series with the main transformers, the secondary of the charging transformer being on open circuit; the resistance of this secondary is gradually cut down by means of a water rheostat, the main fuse being eventually put in, and the charging transformer cut out. In switching off the mains the reverse operation takes place.

There are two trunk mains, one for each phase, consisting each of paper-insulated concentric cables, and also an extra one laid alongside as a spare main. The mains are laid under the canal towpath in a cast-iron channel of five ways, with a loose cast-iron lid; full descriptions are given of the disconnection boxes and of the jointing and laying of the cables. At the substations the pressure is reduced to 1,000 volts. The switch gear is similar to that employed at Willesden; all pressure regulation is done in the substations. There are also a small test transformer and suitable plug switches on the board, for the purpose of ascertaining on which side of the system the extra main has been placed at Willesden in the event of the spare main being required.

The article is fully illustrated, and a complete account is given of the scheme. E. D. P.

1372. *Polyphase Distributing System of the Metropolitan Street Railway Company of New York City.* **J. E. Woodbridge.** (Elect. World and Engineer, 35. pp. 463–464, March 31; 501–504, April 7; 541–544, April 14; 579–581, April 21; 613–615, April 28; and 698–701, May 12, 1900.)—The lines owned, leased, or operated by the Metropolitan Co. aggregate about 217 miles of track, of which 82 miles is at present worked electrically. Quite recently the Whitney Syndicate which controls the Metropolitan Co. has obtained a controlling interest in the Third Avenue Railway Co. (58 miles of track), and the Union Railway Co. (55 miles of track), so that altogether the lines which will be operated from the station now approaching completion will in about a year have 3,000 cars in their sheds, or about 1,500 in actual operation at one time.

The generating plant will, when completed, consist of eleven main engines each rated at 4,500 H.P. with cut-off at maximum economy, but capable of working up to 7,000 to 7,500 H.P. apiece.

The following are the leading particulars of the eleven three-phase generators:—

Type: Revolving field with external stationary armature mounted between the two halves of the vertical engine.

Output: 3,500 kw. normal, or 5,000 kw. for four hours; voltage, 6,600; frequency, 25; speed, 75.

Shaft: Compressed steel 37 inches diameter, being the crank-shaft of the engine, the spider secured by two keys each 5 in. × 2¼ in. section.

Spider of the field ring has eight arms cast in one piece with the hubs, the fly-wheel hub being bolted up *direct to the arms* by sixteen 2¼-inch bolts at a distance of 4 feet from shaft centre.

Field Ring of cast steel in four sections, each half the full axial width of the ring, and each spanning half the circumference. The rim tension of these rings is carried across the butt joints by means of double-headed keys similar to those commonly used in fly-wheels.

Poles: 40 in number made of laminated steel with an edgewise winding. Overall diameter 16 ft. 8 in., giving a peripheral speed of 3,900 feet per minute.

Excitation: The exciting current at 100 to 125 volts is introduced to the revolving field coils by carbon brushes bearing on *cast-iron* rings. The resistance of the field is ⅛ ohm, the necessary exciting current for full voltage from the armature (6,600) with non-inductive load being 800 amperes.

Air-gap: $\frac{5}{16}$ inch at pole centre, to $\frac{11}{16}$ inch at the tips. It is purposely made narrow, and the magnetism has been carried fairly high on the saturation curve, because by working at a high line-density the magnetomotive force of the armature reaction is unable to cause as great a change of the field strength as it would if this density were down on a steeper portion of the magnetisation curve. On this account the throwing off of the full non-inductive load causes a rise in voltage of only 5 per cent. The short air-gap reduces the number of necessary field ampere-turns, to which the armature short-circuit current is directly proportional, thus cutting down the latter to the low figure of rather less than 800 amperes per leg, the rated full-load current being slightly over 300 amperes.

Armature ring of cast iron, 21½ feet external diameter, mounted on sliding foundation plates so that it can be moved axially to clear the field.

Armature coil built up of laminated steel with eight ventilation spaces. The core bolts do *not* pass through the plates.

Armature winding: On account of the high potential, 6,000 to 6,600 volts, the winding is carried in a few large slots per pole rather than a large number of small ones. There are six slots per pole, two per pole per phase, each 1¼ in. × 3¾ in., deep, and containing former-wound coils, the ends of all coils of two of the phases being bent back to clear those of the third phase, making what is known as the double-chain winding. The connections are such that all the turns of each phase are in series with each other, the three phases being **Y** connected.

Efficiencies: 1¼ load, 97 per cent.; full load, 96·7 per cent.; ¾ load, 96·2 per cent.; ½ load, 94·8 per cent.; ¼ load, 90·8 per cent.

Weight: The complete machine weighs 130 tons, the rotating part accounting for about half of this.

The designers appreciated the risks that would accrue were 6,600 volts allowed to concentrate itself on a single fault. On account of this and the widespread character of the public service which would be interrupted by a shut down, all routes over which the power is carried from part to part of the station, as well as from it to the substation, is divided as much as possible. For instance, the conduits which carry the cables from the generators to the switchboard gallery are several in number, and widely separated from each other, the same being true of the vertical cable ducts. Again, although for convenience of operation there is one switchboard, yet much trouble has been taken to distribute the switching apparatus itself over a much greater area than would, for purely mechanical reasons, be necessary. Thus each switch and each pole of each switch or circuit-breaker is placed within its own cell, separated by brick walls from the other cells, and by double brick walls and intervening air spaces from other switches or circuit-breakers.

The circuit-breaker is of the oil type and is operated by compressed air forcing a piston up or down in a vertical cylinder above the top of the brick structure, enclosing the live parts. The valve controlling this cylinder is operated by one magnet. When the magnet is excited and draws its armature down, it pulls a valve—which is a miniature of the plain unbalanced **D** valves of simple engines—into such a position as to admit air above the piston and exhaust it below, thus forcing the piston down and closing the main current contacts. If current is cut off from the magnet by any means the valve is instantly restored by a spring into such a position as to admit air below the piston and so open the contacts. The magnet is wound with two coils, one of fine and one of coarse wire connected in series with each other. The movement of the armature works an automatic switch which short-circuits the high resistance part of the winding when the armature is up, thus allowing a powerful current to pass from the constant potential source of supply to draw the armature down with plenty of reserve force. As soon as the armature is down, the increased resistance thrown on by the automatic switch reduces the flow of current through the magnet winding to an amount only sufficient to hold the armature in the down position, thus economising current which must be left on as long as the oil circuit-breaker is closed. The exciting current is at 110 volts, and the compressed air for the pneumatic cylinders is supplied by motor-driven air-pumps with automatic controllers.

Comparisons are made between the new type of circuit-breaker and the old type in which three magnets were used. A description is given of the automatic controlling switch with differential magnet for reverse current protection; and also a detailed account of the method of arranging the 'bus bars and various circuits on the switchboard. Numerous illustrations and diagrams are given.

The last and sixth article deals with the high-tension feeders and the substations. The feeders are triple conductor cables, each conductor having a cross section equivalent to 4/0. Each cable end is flared out to bell-mouth form to prevent static discharges from piercing the insulation at this point, and static dischargers (which are the same as lightning arresters) are also connected to each end. At the generating station the circuit-breaker, through which the current passes to the feeder, is fitted with an automatic overload relay, and again at the substation the circuit-breaker is fitted with an automatic releasing device actuated by a reverse current relay. In case a short occurs on any feeder, there will be a rush of current into it from the generators which will operate the overload relay, and at the same time the rush of power back into the other end of the feeder from the substation 'bus bars, operates the reverse current relay. In this way the feeders are at once cut out of circuit at both ends.

There are six substations, each with from three to six 1,000-kw. rotary converters. The step-down transformers—three to each converter—are of the ir-blast type, and reduce the voltage from 6,000 to 350. [See also following bstract.] E. K. S.

1373. *Power Stations of Metropolitan Co. and Third Avenue Railroad Co., New rk.* (Tram. Rly. World, 9. pp. 57–61, Feb., 1900.)—*Metropolitan Company.* System: Conduit, three-phase distribution. The boiler-room contains forty-e ht Babcock boilers on three floors. Each boiler has 2665 square feet heating s ace, 160 lbs. pressure. Coal is stored in two 5,000-ton bunkers by boat-u ading and conveying machinery. It is delivered into mechanical stokers th gh shutes. The engine-room contains eleven 6,000 I.H.P. Allis vertical cr -compound Corliss condensing engines, having cylinders 46 inches and 86 ches in diameter, 60-inch stroke, running at 75 r.p.m. Each engine dri directly a G.E. 3,500 kw. stationary armature three-phase 6,600 volt gen tor. Each of the five substations contains 350-kw. step-down trans-forn s, and 990-kw. rotary converters transforming to a pressure of 550 volts. The bstation capacity ranges from 3,000 to 5,000 kw., which it is subse-quen proposed to increase by the use of accumulators. The conduit syste will be in use on 220 miles of track. Drawings: Scale plan, and sectio f generating station. [See also preceding Abstract.]

Th Avenue Railroad Company.—System: Conduit. The boiler-room will c in sixty Babcock boilers on two floors. Working pressure 200 lbs. Coal be stored in a bin of 10,000 tons capacity, and fed through mecha l stokers. The engine-room will contain nearly 100,000 H.P. of 7,000-H vertical cross-compound condensing Westinghouse engines, having inders 48 inches and 86 inches diameter, 60-inch stroke, running at 75 r.p Drawings: Scale plan of generating station. J. T. R.

1374. *emont Three-phase Railway, Ohio.* (Street Rly. Journ. 16. pp. 227–231, Mar 1900.)—This is a description of the long-distance, electric, high-speed railway between Toledo and Norwalk. The entire length of the line —sixty miles—will be supplied with current from a central power station at Fremont, from which current will be transmitted at high pressure, thirty miles in each direction, to six substations, where it will be transformed down and converted to direct current for feeding the trolley lines. The boiler house contains five Babcock-Wilcox boilers, each of 300 H.P. nominal rating and working at a pressure of 155 lbs. per square inch. The feed water is pumped from the Sandusky River through one 6-inch and two 14-inch pipes. Two Worthington pumps lift the water from the intake well to two elevated jet condensers which are set over a single hot well. The feed water is taken from this hot well by a Worthington tank-pump to the treating plant. When neither of the condensers are running, the feed water is drawn direct from the river through the 6-inch suction-pipe by the Worthington tank-pump ; or should this pump be disabled, the feed-pump can draw the water from the river well direct through the same 6-inch pipe. The water is treated in two large tanks provided with stirrers worked by electrical power. It is afterwards run into a large filter tank, constructed of Portland cement masonry, which is fitted with a sand filter bed, aluminium-bronze strainers, washing pipes and stirring devices. After leaving the feed-pumps the water passes through an auxiliary heater, where it receives the surplus heat of the auxiliary pumps and engines, thence through an economiser to the boilers. The feed-piping is so arranged that either the heater or economiser may be by-passed. There is coal storage above of 500 tons capacity from which the coal is fed b gravity to the mechanical stokers. The ashes and refuse are also convey mechanically to a bin. A branch line of the Wheeling and Lake Erie Railwa passes under the refuse bin, and also over the coal-handling plant, whic consists of an endless chain of wheel and pan construction. The coal and a handling machinery is operated by a 10 H.P. Westinghouse Standard engi. Draught is furnished by two vertical discharge fans, directly connectedo horizontal engines, which are fitted with a regulator whereby the spd is increased as the steam pressure falls, and *vice versâ.*

A compressed-air system has been installed for cleaning the electal machinery. It consists of a Westinghouse Air Brake Company's standar ir-pump, storage tank, &c. Four 1,000-H.P. vertical compound engines are be installed, having steam cylinders of 21·5 in., and 37 in. × 22 in. ske, and running at 214 r.p.m. Each of these Westinghouse engines is dctly coupled to a 500-kw. Westinghouse three-phase generator. Special vices are to be provided to enable the speed of any engine to be varied fr the switchboard. Excitation is provided by two 30-kw. direct coupled Vsting-house sets. Each of these sets is capable of supplying the main geators and the works lights.

The transformer room is under the engine-room, and will be uipped with two banks of three transformers, each of 400-kw. of the Wesghouse oil-insulated self-cooling type. There will also be two 200-kw. Weghouse rotary converters installed at the generating station, taking curren om the main 'bus bars to supply the contiguous sections of the line. e whole system, both the main generators and the substation plant will arranged for parallel running. The switchboard arrangements are of the ual kind. Time-element circuit-breakers are installed. The pressure of th ain transmission three-phase line is 16,000 volts ; each wire is protected by ,000-volts Wurts lightning arrester. Each of the six substations contain o 200-kw. Westinghouse converters and three 150-kw. step-down transfor rs. Loops are brought out of these transformers to effect different r of transformation, so that the pressure on the trolley line may be equalised in different substations. The high tension current is carried by three bare copper wires, one upon each end of a cross arm and the other on the top of the pole. Six feet below the cross-bar is the bracket carrying the trolley wires. On the opposite side of the pole, just above the bracket, are carried the direct current feeder cables. The track is single, with turnouts. Cedar ties are used, ballasted with gravel and stone ; Carnegie 75-lb. T rails, Forest City Electric Co. bonds, and cross-bonds every 500 feet are employed. The passenger cars are equipped with two 75-H.P. Westinghouse railway motors, sufficient for a speed of 50 miles an hour on a straight, level track, and are fitted with Westinghouse air brakes. The car bodies are mounted on the Barney and Smith improved Class F truck, especially designed for heavy work. Spoke wheels, 36 inches diameter, will be used with axles of hammered iron 5·375 inches diameter. The cars have a seating capacity for 50 passengers. The substations along the line will serve as points for the collection and distribution of freight. Mileage books for 1,000 miles will be sold for 12·50 dollars, and the local fares will be about one-half of those charged by the steam railroad. E. D. P.

1375. *Exeter-Amesbury Railway, U.S.A.* (Street Rly. Journ. 16. pp. 232–234, March, 1900.)—An illustrated description of the electric railway laid along the highway between Exeter and Amesbury, a distance of twenty miles. The generating station is at Hampton. The boiler-room contains three Ames' horizontal tubular boilers of 125 - H.P. each, and one 150 - H.P. Dillon boiler. Water is drawn from an artesian well 154 feet deep. The feed-water heater is of the Lamphear compound type, in which the auxiliary heater is placed inside the primary heater. The feed-water is passed into the primary heater coils receiving the heat due to the exhaust steam of the engines exhausting into the condenser. This temperature is about 120°–130° F. At the opposite end from which the water enters, it passes into the auxiliary heater, through a lower set of tubes to a settling chamber, then through the upper set of tubes to another chamber, and thence to the boilers. The auxiliary heater receives the exhaust steam of the pumps at the top, whence it passes down round the tubes and out to the atmosphere or the hot well. It is seldom that any steam is seen coming from this outlet, the condensation in the heater being so effective. The temperature of the feed water from the heater, at a distance of 12½ feet, with everything running, is about 210°–212° F. The pumps and condenser, 800 H.P., are all of the Davidson make. The engine-room contains one cross-compound Buckeye engine, cylinders 16·5 in. and 30·5 in. × 30 in. stroke, 350 H.P., directly coupled to a G.E. generator of 250 kw., running at 120 r.p.m. Also two simple Buckeye engines, cylinder 15·25 in. × 24 in. stroke, 180 H.P., running at 160 r.p.m., and belt coupled to two Keystone generators of 125 H.P. each. In addition, for lighting purposes, there is a tandem compound Buckeye engine, 175 H.P., driving by belts an 80 arc light Brush machine and a G.E. alternator of 1,500 lamps capacity. The car house, 250 ft. × 50 ft., is separate, and can accommodate twenty-four cars. In the rear are six pits with brick sides and cement bottoms, and in the front is a cement floor where the cars are washed. At the rear of the car house and separated from it by a fireproof wall is a repair shop and stock-room. The overhead line is mostly of the side pole construction, with Creaghead flexible brackets. The track is of T rails. The rolling stock consists of eight fourteen-bench open cars, ten ten-bench open cars, nine closed cars, and two freight cars, also several Taunton ploughs. Two motors of 35 H.P. each are used on the ten-bench cars, and two 50-H.P. motors on the closed cars. The car trucks are of the Dupont make. There is a branch line to Hampton Beach, a popular pleasure resort. E. D. P.

1376. *A Hill-side Electric Tramway, near Rouen.* (Tram. Rly. World, 9. pp. 109–112, March, 1900.)—System : Overhead trolley, continuous current. The boiler-room contains two Babcock boilers with a heating surface of 1,880 square feet, 176 lbs. working pressure. The engine-room contains two 200-H.P. horizontal condensing engines, having 16 ft. 4 in. flywheels weighing sixteen tons, and running at 200 r.p.m. Each engine drives by a leather belt a 150-k.w. 560-volt Westinghouse generator. Rain water is collected in reservoirs for condensing, and is returned after passing through water coolers. Along the track, wood, and in the town, iron, poles carry by means of span wires, and at some points brackets, a ⅜ in. trolley wire 21 ft. 3 in. above the track. The rails are of grooved girder type 83 lbs. per metre on public roads, and 56-lb. tee rails elsewhere. The track is single, with passing places 500 metres long. There are six closed motor cars mounted on Peckham trucks, each fitted with two 35-H.P. Westinghouse motors. There are six open trailers. The motor cars and trailers combined have a capacity of forty-eight passengers. In order to avoid steep gradients, costly retaining walls and cuttings have been constructed. The cars are not fitted with special power brakes. J. T. R.

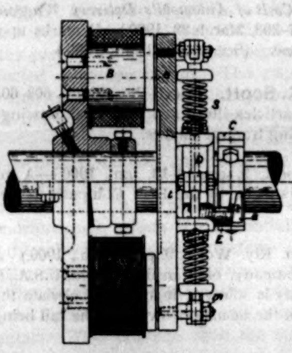
1377. *Electric Railways in Italy.* **K. Neudeck.** (Zeitschr. Elektrotechn., Wien, 18. pp. 106–107, Feb. 25, and 116–118, March 4, 1900.)—Particulars are given of the Monza-Milan line worked by accumulators, the Milan-Leveno-Varise line, which is to be 112 km. long, and the Bologna-San Felice line, 42 km. long. This article is, however, principally interesting because of particulars which it gives of the Lecco-Colico-Londrio-Chiavenna line, 116 km. long, which Ganz and Co., of Buda-Pesth, are now equipping for the Adriatic Railway Company. This line is to be operated by three-phase currents generated at the power station on the River Adda at 15,000 volts, and transformed down to 3,000 volts on the trolley wires. The two trolley lines (the rails form the third conductor) are spaced 3 feet apart, and they are fed with current from substations, which are 10 km. apart. The line is divided into sections, each being supplied with current from the substation next beyond it. This gives great safety in working, for when a block signal indicates "Stop," the next part of the line is not supplied with current. Moreover, in case of interruption of current the Westinghouse brakes come on automatically.

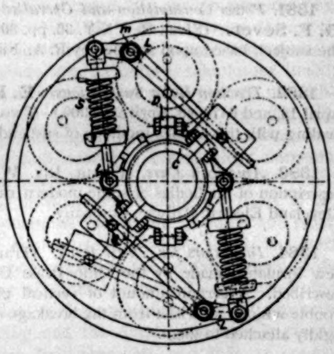
The passenger trains consist of one motor car and one trailer. Each motor car has four motors, but is usually driven by only two, the normal speeds being 60 and 30 km. per hour, according to whether the train is on the level or on a gradient. The freight trains have a maximum capacity of 200 tons, and are hauled by a locomotive car. They run at 30 and 15 km. per hour. E. K. S.

ELECTRIC TRACTION AND AUTOMOBILISM.

1378. *Buffer Batteries for Electric Traction.* **E. Sieg.** (Elekt. Runds. 17. pp. 91–92, Feb. 1, p. 105, Feb. 15, 1900 ; Elektrotechn. Zeitschr. 21. pp. 226–228, March 15, 1900. Paper read before the Elektrotechnische Gesellschaft of Cologne.)—The effect of buffer batteries in electric traction systems in equalising the dynamo load with the consequent saving in capital expenditure and in wear and tear in the machinery is explained. Such batteries were first employed at Zurich in 1893 and Remschied in 1895, and are now becoming general in Continental traction stations. In the Remschied station the battery of 260 ampere-hour capacity reduced the maximum dynamo output from 190 to 95 amperes, and the variation in voltage on the 600-volt line from 200 to 37 volts. The larger the capacity and the lower the internal resistance of the battery the more perfect is its steadying effect. The resistance lies mainly in the electrolyte, the drop in voltage in each cell due to this resistance being 0·0015 × distance between the plates (m.m.) × current density in amperes per square decimetre. As the discharge proceeds the resistance of the active materials rises with corresponding drop in the terminal voltage. By means of a subsidiary electrode the seat of the potential drop can be determined, and curves of this drop traced for various discharge rates. The effect of form of plate on this potential drop is discussed. The diagrams and curves accompanying the original paper are reproduced in the Elektrotechn. Zeitschrift only. L. B.

1379. *Electric Brake.* (Tram. Rly. World, 9. pp. 66–67, Feb., 1900.) —The Helios Electrical Company of Cologne has introduced a brake on the Landsberg cars, in which use is made of Foucault currents. The cars have a motor on one axle and the brake on the other, the latter being used only to check the motion, and so prevent wear and tear on the brake shoes, and wheel tyres. A mechanical brake comes into use to bring the car to a standstill. The electric brake consists of two chief parts—the electromagnets, B, which are prevented from rotating by being fixed to the truck, and the armature, *a*, which is keyed upon the axle in such a way that while it rotates it may have at the same time a slight horizontal movement along the axle. This horizontal movement is effected by means of fly weights attached to the levers L, which open and close according to the speed of the axle, a projection E on the ring D engaging with the inclined grooves *e* of the ring C.





The brake magnets are excited by the motor, which acts temporarily as a generator; thus both axles are braked, the one by the motor acting as a generator, and the other by Foucault currents engendered in the armature of the braking apparatus. When the brake is first applied the exciting current in the brake magnets is relatively strong, but as the speed of the car decreases, it falls off; at the same time, however, the flyweights close in towards the axle, and thus cause the armature to approach the pole-pieces, so that the air space, and therefore the magnetic resistance, being diminished, the efficiency of the brake, compared to the first effect obtained, remains nearly the same. It may be mentioned that the effect obtained by the mechanical action of the flyweights is assisted by the action of the Foucault currents, giving an effect during the decrease in speed, which is in the same direction as the displacement. E. K. S.

1380. *Trolley Motor Car.* **É. Hospitalier.** (Ind. Élect. 9. pp. 45–48, Feb. 10, 1900.)—For extensions to tramways and on country routes, which cannot afford the capital expenditure necessary for track, Lombard-Gerin suggests a double trolley line, along which there runs a small motor connected to the car by a flexible extensible cable. The current which propels the trolley motor is derived from the motor on the car, and its speed depends on the speed of the car. The trolley and motor weigh 18 kgs., and take at top speed 500 watts. The trolley motor is actuated by three-phase currents taken off the direct-current motor. M. O'G.

REFERENCES.

1381. *Power Consumption and Operative Costs of Automobile Delivery Waggons.* **G. F. Sever.** (Elect. Rev. N.Y. 36. pp. 307–308, March 28, 1900.)—Remarks upon the subject, based upon a paper by R. A. Fliess. (See 1900, Abstract 950.)

1382. *Traction-Motor Suspensions.* **E. K. Scott.** (Elect. Rev. 46. pp. 603–605, April 13, and 647–648, April 20, 1900.)—Two articles, illustrated by several drawings, dealing with the various methods of suspending tramcar motors.

1383. *American Cars.* (Tram. Rly. World, 9. pp. 12–13, Jan., 1900.)—A full description of the bodies of some modern cars made by the Brill Company for the Cleveland Electric Railway Company.

1384. *Insulators for Third Rails.* (Tram. Rly. World, 9. p. 13, Jan., 1900.)—A new insulator, made by the Ohio Brass Company, of Mansfield, Ohio, U.S.A., is described. A certain amount of vertical play is allowed in order to obviate the trouble which has arisen from the breakage of the insulators owing to the rail being rigidly attached to them.

1385. *Electrical Driving of Factories.* **A. H. Gibbings.** (Elect. Rev. 46. pp. 551–555, March 30, 1900. Paper read before the Northern Society of Electrical Engineers, Manchester, March 13, 1900.)—This paper contains two tables of interest. The first gives the number of motors on the circuits of a large number of towns in England, together with the number of units sold for motor purposes by each; and the second gives some tabulated particulars about thirty motor installations in Bradford, showing that in general motors have been found to be cheaper than gas engines.

1386. *Electric Lighting Cable Breakdowns.* **G. Kapp.** (Elect. Rev. 46. pp. 380–383, March 9, and 471–473, March 23, 1900.)—Translation of paper referred to in Abstract No. 755 (1900).

TELEGRAPHY AND TELEPHONY.

1387. *Improvements in Wheatstone's Automatic Telegraph.* (Elect. Rev. 46. pp. 840–841, March 2, 1900.)—This article describes improvements in the transmitter and the perforators, by J. Willmot. In the former the contact lever, instead of being held over to the contact-points by means of a spring and jockey roller operating upon the end of the lever, which arrangement required a large play of the lever and much downward pressure, as well as the use of a lubricant, which is objectionable in the neighbourhood of electrical contacts, is retained in place by a permanent magnet, which is said to obviate these difficulties. The force necessary to drive the instrument is also less. Improvements in pivotting of the crank levers and horizontal levers are also detailed. The punch of the perforator has hitherto suffered much wear by the deposits of oil from the paper giving it a convex form, and the cut-out portion being thus bent over the edge of the punch. The cut paper is also from this cause sluggish in dropping out. Willmott's new punch has a hollow recess at its end, and makes a clean perforation; being hollow, it is more easily ground, and while a perforation is being effected the air within the hollow is compressed, and then tends to blow away the piece of paper the punch has removed. E. O. W.

1388. *Multiplex Telegraphy by the Telemicrophonic Relay.* **E. Mercadier.** (Comptes Rendus, 130. pp. 770–773, March 19, 1900.) A description of the author's "Monotelephones," or telephones "tuned" to certain periodicities, has been already given [see 1899, Abstract No. 1995]. In this system the apparatus permits of upwards of twenty-four transmissions being simultaneously effected over one circuit. The receivers are, as before, telephones tuned, so that each will respond only to a current of a certain period, notwithstanding that currents of other periods are present in the circuit. His telemicrophonic and differential relay is designed to magnify this effect, and to permit of sending and receiving simultaneously. He employs currents, undulating and sinusoidal, varying in period from $\frac{1}{480}$ to $\frac{1}{900}$ of a second by half-tones. A diaphragm 10 cm. in diameter vibrates in front of an electromagnet, which is differentially wound, and which occupies the place of the relay in the ordinary systems of duplex telegraphy; the line is balanced in the usual way. A little plate of carbon is fixed to the centre of the outside of the diaphragm, and another piece of carbon, attached to a metal stud at the extremity of a long, thin, vertical spring, completes the microphonic contact. This contact, with the spring and the diaphragm, are in circuit with a battery and the primary of an induction coil, and it is, of course, actuated when the diaphragm moves under the influence of undulatory currents arriving from a distant station. The twelve receivers are in circuit with the secondary of the coil, and are, as has been stated above, "tuned," so as to be selective of that one current which has the appropriate periodicity. The microphonic, or rubbing carbon contact, reproduces the effects of all the undulatory currents that are flowing in the one circuit. Screws regulate the distance of the diaphragm from the electromagnet, and also the pressure of the carbon contact. The system has been practically tried on circuits of 600 to 800 km. in length, and is evidently adapted either for two or more than two stations by intercalation in series or in derivation, upon any circuit where a telephone can work. E. O. W.

1389. *Snow on Phosphor Bronze Wires.* **E. Piérard.** (Soc. Belge. Élect., Bull. 17. pp. 52–55, Jan., 1900.)—On short lengths the weight of snow may be twice or even four times the weight of the wire, and thus reach the breaking point. On lengths of 500 metres, however, the wire would stretch to the roof or ground, and hence would never break from this cause. M. O'G.

1390. *Ducousso's Telephone Switchboards.* **L. Montillot.** (Électricien, 19. pp. 177–181, March 24, 1900.)—These are arranged in two ways. In the one the operator is able to place the Exchange telephone in derivation during a conversation, and in the other, or "secret" system, the operator cannot do so. Each line has its own indicator, calling-key, jack, cord, and plug peculiar to itself. In the first system the operator has a plug and cord connected to her apparatus; in the second system these attachments are dispensed with and the apparatus is connected to a jack on the board. On the one hand, therefore, she is able to answer a call, or to listen to a communication, to put her plug in any jack on the board; but, on the other hand, in the "secret" system, she must, to answer a call, put the subscriber's plug with its cord attached into her own jack, and, having ascertained what is wanted, remove the same plug and insert it in the jack of the line required. She is thus cut off from the circuit being used. But the cord and plug of the subscriber called are still hanging idle and might, with the ordinary connections, be used by the operator in her own jack to overhear a conversation. This is rendered impossible by so arranging the springs of each jack that, upon the insertion of a plug, the jack's own plug is cut out of connection.

A commutator or switch is mounted upon the board by which one of three connections of the ringing circuit is effected; that is, when a subscriber calls there is a continuous ringing, a momentary ring, or none at all, the only indication in this last case being the fall of the drop. E. O. W.

1391. *Underground Telephone and Telegraph Work.* (West. Electn. 26. pp. 159–160, March 17, 1900.)—A description with plan and illustrations of the tunnel work in Chicago of the Illinois Company. The tunnels are 8 feet high with a maximum width of 6 feet. The floors are 33 feet below the surface of the streets, so that by means of shafts here and there throughout the city work is carried on with no disturbance of public traffic. To keep the earth from falling in as the drifts are advanced, all the work is done under an air pressure of about 10 lbs. above the atmosphere, the usual air locks being provided. Lateral tunnels branch off to buildings underneath the pavements and rise to the surface without manholes in the streets. The laterals are 3 feet in diameter. Both tunnels and laterals are lined with Portland cement, the former for 10 inches and the latter for 8 inches of thickness. All wires and cables will be carried on racks at the sides. The temperature in the tunnels varies from about 75° to 80° F. The lighting is by incandescent electric lamps, naked lights being avoided owing to danger from gas leaks. The bottoms of the drifts are graded to carry off moisture, of which there is very little at present, but if it collects it will be pumped out. The tunnels are said to be the only ones of their kind constructed entirely of cement. The Exchange system is to be automatic, for which no help is required at the central. It is said to afford entirely secret communication. The company intends to wire all buildings with which it deals, so that a telephone can be put in each room, and to furnish instruments on a meter system, at a charge of 5 cents for each call above the ordinary subscription up to a maximum, with the latter, of $85. It is estimated that 50,000 telephones can be thus supplied in Chicago. E. O. W.